12 Jan 07

Letter Head

DEPLOYED ANALYST HANDBOOK

PREFACE

The purpose of this handbook is ….

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INTRODUCTION

1. Purpose of Handbook.

a. Reference Guide. This handbook is intended to be a quick reference guide for all deploying analysts, both military and civilian. The handbook will present the analysts with a wide range of topics from military terms and symbols to specific analytical products an analyst can expect to execute.

b. Highlight Analyses. A major portion of the handbook will highlight analysis conducted by previously deployed analysts. The discussion and examples will stress the types of analysis that an analyst can expect to conduct in the future. These expectations were developed using results from the Deployed Analyst Survey.

c. Examples. Throughout the main body of the handbook there will be examples of analysis, the assessment process, data management, surveys, and reachback capabilities. The Annexes will provide greater detail on examples previously conducted in theater and provide examples of analysis one may expect to conduct in the future.

2. Motivation for Using Handbook.

The information contained in this handbook was developed based upon results of the Deployed Analyst Survey and the experience of numerous Center for Army Analysis (CAA) analysts that deployed to both Operation Iraqi Freedom and Operation Enduring Freedom over the past several years. This handbook provides the lessons learned and best practices of analysts who have supported the warfighter at all levels of command. This handbook will better prepare analysts to provide analytical support to their command and staff while also obtaining knowledge on where to seek additional analytical help through the reachback process.

CHAPTER I: COMMUNICATING OR CAPABILITIES

1. Operations Research - General

a. Definition. What is Operations Research? All OR analysts know that it is difficult to concisely answer this question without using words like stochastic, combinatorial, and heteroscedasticy. However, being able to answer this question and effectively communicate the OR profession is critical to your success as a deployed OR analyst – your success is often as dependent on your communicating skills as it is on the quality of your work.

As an OR analyst in the military, and even more so as a deployed OR analyst, you do not have the luxury of additional resources to assist in communicating the OR skills to the command. You must perform the analysis and communicate your profession at the same time.

This chapter is designed to teach you how to make leaders aware of OR capabilities. Specifically, it will teach you (1) how to concisely explain the OR profession in the military, (2) valuable applications of the OR skill set in a deployed environment, and (3) the essential elements of an OR marketing plan. Much of the content of this chapter parallels documents produced by INFORMS on marketing the OR profession; however, the ideas have been modified to be more relevant and applicable to a deployed military analyst.

b. How to Concisely Explain the OR Profession in the Military. This section provides you with some simple, succinct verbiage to help you concisely explain OR and its value. You should commit to memory the ideas in this section so that you are capable of using them regularly in conversation.

(1) Who are you? Use one name consistently: *you are an Operations Research Analyst*. That is how you should introduce yourself at all opportunities. If you say it often enough, people will start to believe that OR must be important.

(2) What do you do? As an OR analyst in the military, your job is *to apply advanced analytical methods to help military leaders make better decisions*. Memorize the previous sentence. Say it every time someone asks you what you do.

(3) What is your skill set? An OR analyst's skill set spans three major subject areas:

(a) *Probability and Statistics* involves the analysis of data in order to gain valuable insights, measure risk, and make reliable forecasts.

(b) *Optimization* quantifies options and helps you to select one of the best options when faced with a complex problem having many decision alternatives.

(c) *Simulation* involves modeling existing processes in order to test new approaches and identify strategies for improvement.

(4) How do you apply your skill set to military problems? Examples include:

(a) Analyzing Significant Event data in order to identify spatial and temporal trends

(b) Developing strategies to effectively allocate or employ limited resources

(c) Improving supply chain and logistics operations to include developing favorable loading, transportation, and distribution plans

(d) Conducting qualitative and quantitative assessments of current operations

(e) Measuring risk and uncovering factors critical to managing and reducing risk

(f) Evaluating the potential benefit of changes in tactics, techniques, and procedures

(5) How does someone know that they could benefit from OR? In order to sell OR to others and recruit customers, you need to convince people that applying OR techniques will improve their processes. Listed below are some signs that a potential customer could benefit from OR:

(a) He has a lot of data, but does not feel he is using it to his full advantage.

(b) He manages data using Microsoft Excel, but is convinced that he is not using Excel to its full capability.

(c) He needs help displaying his data effectively to senior leaders.

(d) He is facing a complex problem with many decision options. He suspects that some of the options are better than the others, but he needs a way to analytically evaluate all options and choose one of the best.

(e) He is troubled by risk. He wants to find effective strategies for limiting or reducing risk.

(f) He wants to measure some effect or impact, but he is not satisfied with the metrics he is using.

2. Operations Research – Deployed Analyst

a. Valuable Applications of the OR Skill Set in a Deployed Environment. Now that you have some ideas on how to explain OR and its value, you need to be aware of the most common applications of the OR skill set that will be valuable to your command while you are deployed. Odds are that you will not be using many advanced OR techniques as a deployed analyst. It is more likely that you will:

(1) Help individuals more effectively manage their data

(2) Quickly analyze large amounts of data

(3) Discover effective ways to present data to senior leaders

(4) Teach beginning and advanced Microsoft Excel and PowerPoint skills

(5) Use your critical thinking skills to develop strategies for solving problems

It may not seem like much, but contributions like this can pay dividends for a command. Even if the help you provide seems minor, it might save your customer many hours of work.

Take, for example, the use of Microsoft Excel. OR analysts use Excel regularly and can do amazing things: pivot tables, pivot charts, linking data to PowerPoint, using Visual Basic to automate tasks, etc. Outside of the OR community, people have never heard of these capabilities. Thus, they use Excel very inefficiently because they do not know that there are better ways to manage, track, analyze, and display their data. Simply helping these people manage their data more effectively, and teaching them Excel and PowerPoint skills to summarize and present their data, will save them a tremendous amount of time and will add great value to their process. There will be many people in your command that need this assistance; it is your job to find them and offer your help.

b. Essential Elements of an OR Communication Plan. Once you can explain OR and are mindful of the most common uses of the OR skill set while deployed, you must be able to market OR through your actions. All of the marketing that you do as a deployed analyst is designed with one goal in mind: *you want to become the go-to person for advice and insight into tough problems*. In this section, we explain

specific actions you should integrate into your OR marketing plan.

(1) Write a charter. The purpose of the charter is to clarify what you do and explain when and why people should seek your help. Make sure it is no more than one page. For content, use the ideas presented earlier in this chapter. Pass out your charter like a business card to new people you meet.

(2) Keep everyone informed about your work. Do not isolate yourself. Be excited about your work and tell people about it. Your work will always be better if you collaborate with others and involve your customers in the process. There are many people who could enhance your work by providing their expert opinion and knowledge, but they will not know you are working on the problem unless you tell them.

(3) Force yourself to have face-to-face interaction with others. This is the best way to get to know a person's problems, issues, and concerns and find out how you can help. It is also the best way for others to get to know you and your skill set. You should spend more time interacting face-to-face than interacting with your computer monitor.

(4) Do not emphasize that your customer has a problem; emphasize your capability to provide improvement to their process. In a military organization, people are very protective of their processes. Telling people that they have a problem is going to get you kicked out of most offices and meetings.

(5) Always leave a "hook" for a follow-on interaction. Once you meet with someone face-to-face to discuss how you can help them, always set a time to meet again. This will help you keep the momentum before your customer loses interest. Say something like "When we meet again at 1000 on Thursday, we can talk about X and Y."

(6) Actively seek out resources: colleagues, mentors, and believers. There will be people in your command who have an OR background or already know the value of OR. Latch on to these people like a leech. Keep them informed of your work and see if they are willing to collaborate with you on OR projects. This is especially important if you are a "lone" deployed analyst – you need to find others with whom to compare ideas.

(7) Expand your customer base. Use this technique to increase your exposure: when briefing or describing your work to others, say "Do you think that it would be useful for Colonel Johnson to see this analysis?" If you get an affirmative answer, then you have a perfectly good excuse to walk right in to Colonel Johnson's office (with reinforcements) and show off your great work.

(8) Start by performing small, simple projects. An OR analyst could spend months mining through a data set. As a deployed analyst, you do not have months to spare – you need to produce results in days or even hours. Good work completed quickly is better than great work that takes forever: you want to get someone an answer while they still remember the question. Performing small, simple analyses will help to educate others about your skill set – once people appreciate your skill set, they will be more likely to give you projects appropriate for your abilities. By solving problems quickly and well, you become the individual of choice for advice on tough problems.

(9) Under-promise and over-deliver. Resist the temptation to promise too much to a customer. If you are given a specific question to answer, always answer the original question asked, then deliver more detailed research and insights than your customer expected. This will demonstrate that (1) you can think critically about the problem and (2) you can be relied on to conduct thorough research; you are not satisfied with just performing the minimum requirement.

(10) Write short, concise reports and simple presentations. Two or three pages or slides at most. If at all possible, keep your results to one page or slide. Write them in simple English so that anyone can understand them. You want people to read your work, and the best way to do that is to keep it brief and simple. If they have questions, then they will call you and you can get together and talk about it. In order to keep your reports and presentations short, make sure that you…

(11) Do not sell the algorithm; sell the results. No one cares that you did a Chi-Squared test with 41 degrees of freedom or a logistic regression with 12 independent variables with interactions. Just tell people what the results are and why they are important. Too many analysts spend way too much time writing and talking about *how* they did the analysis and the challenges that they encountered along the way. Instead, you need to write or talk about the *insights gained* from the analysis and the *conclusions and recommendations* that those insights support.

3. Summary

This chapter was designed to teach you how to market the OR profession as a deployed analyst. Specifically, we covered (1) how to concisely explain the OR profession in the military, (2) valuable applications of the OR skill set in a deployed environment, and (3) the essential elements of an OR marketing plan. Marketing the OR profession is vital to your success as a deployed analyst. However, good marketing does not replace sound analytical work – the two go hand-in-hand. Marketing without sound analytical work is a false promise; sound analytical work without effective marketing goes unnoticed.

CHAPTER II: OPERATIONS RESEARCH MILITARY CONTEXT

1. Basic Graphics and Symbols

Listed below are only general symbols and graphics for quick reference. For an extensive list of terms, acronyms, symbols, and graphics reference FM 1-02 – Operational Terms and Graphics.

a. Symbols (Ref: FM 1-02, Ch. 4 – 9).

(1) Military

(a) Composition - A military symbol is composed of a frame, color (fill), icon(s), and may include text or graphic modifiers that provide additional information. Included in military symbols are graphic control measures, which are composed of boundaries; lines; areas; points; targets; and nuclear, biological, or chemical attacks/events. The composition of graphic control measures varies from that of unit, equipment, installation, and support operations and stability operations symbols.

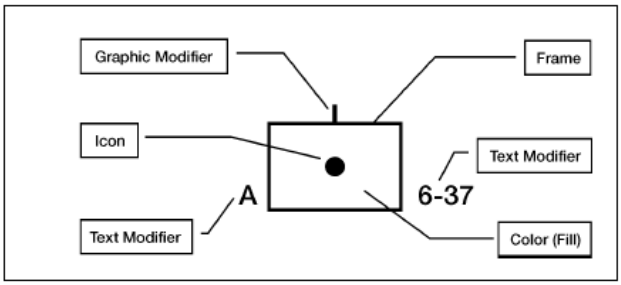

Figure 2.1 Military Symbol Example

(b) Frame - The geometric border of a military symbol. It represents affiliation, dimension, and status.

- Affiliation - The relationship of the symbol being represented to friendly forces. The affiliation

categories are friend, assumed friend, hostile, suspect, neutral, unknown, and pending.

- Dimension - The primary mission area for the symbol being represented. There are five dimensions that can be represented: land, sea surface, sea subsurface, air and space, and unknown.

- Status - refers to whether a unit is known to be present at the location identified or whether it is a planned or suspected location. Regardless of affiliation, present status is indicated by a solid line and planned or suspected status is indicated by a dashed line.

(c) Color – See Paragraph 1.b. (1)

(d) Icon - The innermost part of the military symbol providing an abstract pictorial or alphanumeric representation of the function or role of the military symbol.

(e) Text and Graphic Modifier - Provides additional information about a symbol. This information is displayed on the outside of the frame.

(2) Unit –Unit symbols are composed of a frame, color (fill), branch (an arm of service of the Army/Marine Corps) or functional symbols (icon), and text and/or other symbol modifiers. (See FM 1-02, Ch. 5)

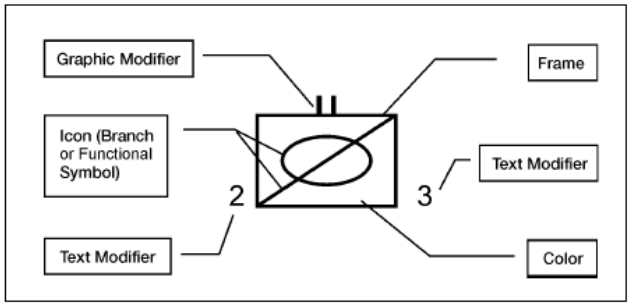

Figure 2.2 Unit Symbol Example

Figure 2.1 above represents the unit symbol for the 2nd Armored Cavalry Squadron of the 3rd Armored Cavalry Regiment. See Paragraph 1.a. (6) for more examples.

Echelon	*Symbol*
Team[1]/Crew	Ø
Squad[2]	•
Section[3]	••
Platoon[4]/Detachment	•••
Company[5]/Battery[6]/Troop[7]	|
Battalion[8]/Squadron	||
Regiment[9]/Group[10]	|||
Brigade[11]	X
Division[12]	XX
Corps[13]	XXX
Army[14]	XXXX
Army Group[15]	XXXXX
Region[16]	XXXXXX

Figure 2.3 Echelon Symbols

(3) Equipment - An equipment symbol is composed of a frame, color (fill), equipment symbol (icon), and text or graphic modifiers indicating type of equipment. (See FM 1-02, Ch. 6)

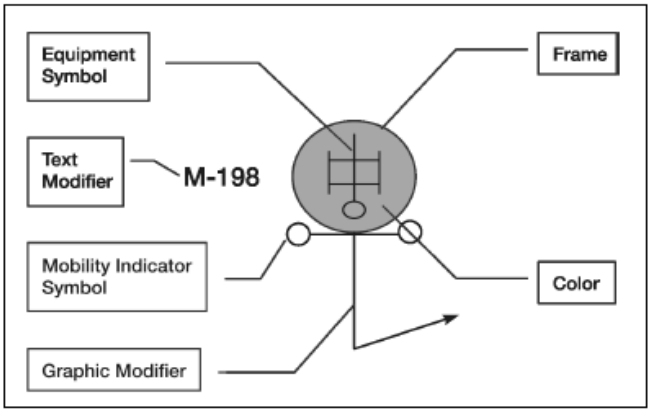

Figure 2.4 Equipment Symbol Example

Figure 2.4 above represents a M-198 - friendly forces towed howitzer (medium). See Paragraph 1.a. (6) for more examples.

(4) Installation - An installation symbol is composed of a frame, color (fill), functional symbol(s) (icon), and text or graphic modifiers. (See FM 1-02, Ch. 8)

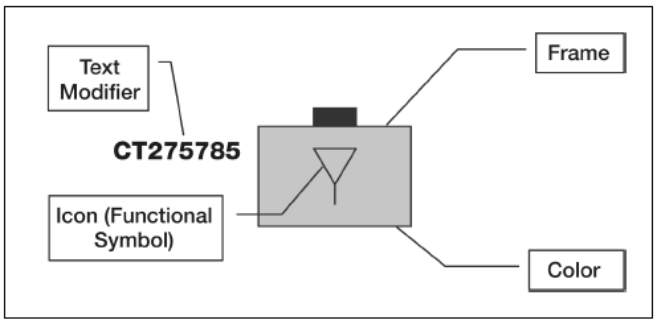

Figure 2.5 Installation Symbol Example

Figure 2.5 above represents a friendly petroleum/gas/oil installation located at Grid CT275785. See Paragraph 1.a. (6) for more examples.

(5) Stability Operations - A stability operations and support operations symbol is composed of a frame, color (fill), stability operations and support operations symbol (icon), and text or graphic modifiers.

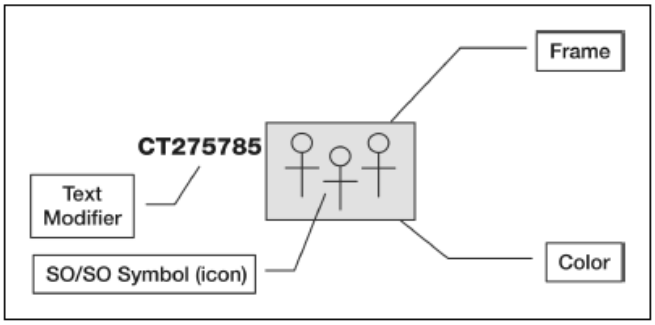

Figure 2.6 Stability Operations Symbol Example

Figure 2.6 above represents friendly refugees located at Grid CT275785. See Paragraph 1.a. (6) for more examples.

(6) Examples

(a) Unit Symbol examples

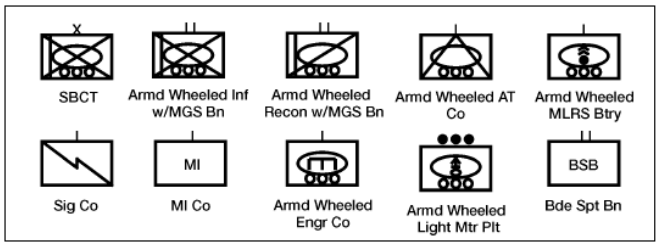

Figure 2.7 Unit Symbol Examples

Figure 2.7 above depicts Stryker Brigade Combat Teams and subordinate units.

(b) Equipment Symbol examples

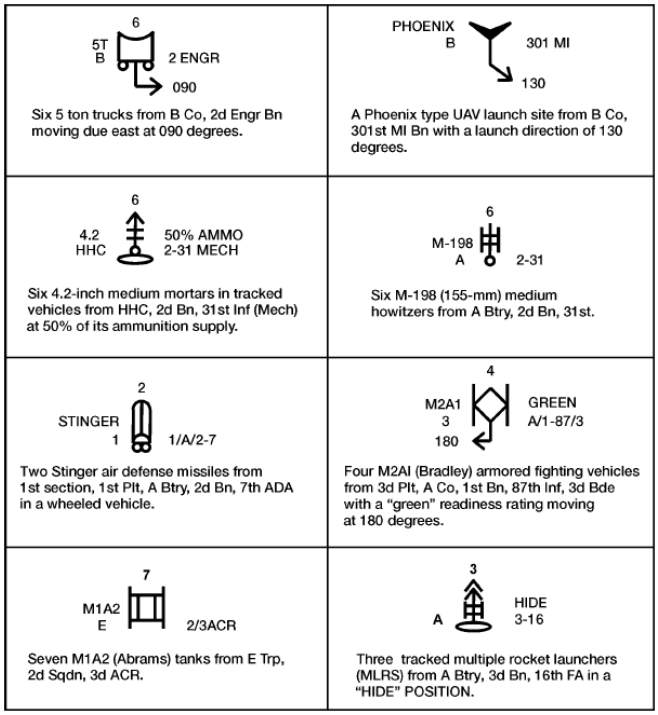

Figure 2.8 Equipment Symbol Examples

(c) Installation Symbol examples

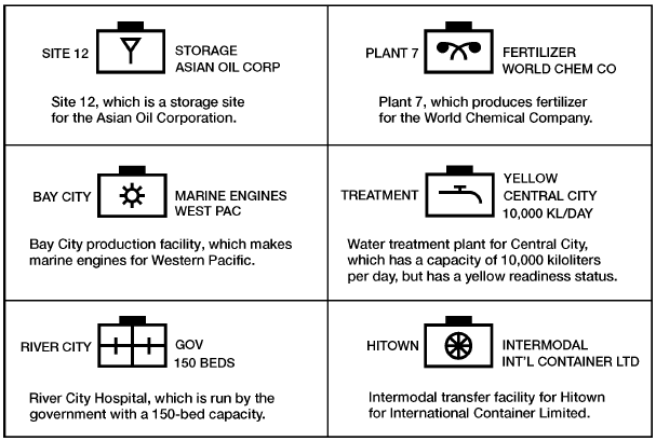

Figure 2.9 Installation Symbol Examples

(d) Stability Operations Symbol examples

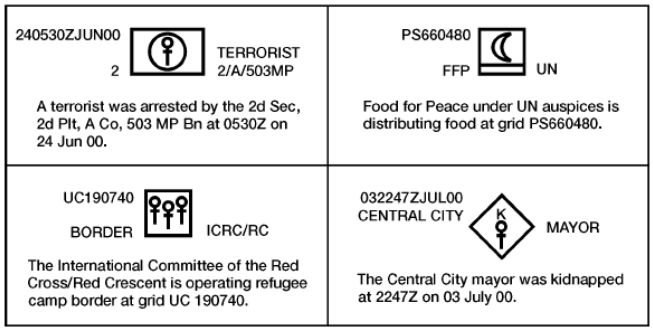

Figure 2.10 Stability Operations Symbol Examples

b. Color Codes.

(1) Colors used for military symbols

Affiliation	Hand Drawn	Computer Generated
Friend, Assumed Friend	Blue	Cyan
Hostile, Suspect	Red	Red
Neutral	Green	Green
Unknown, Pending	Yellow	Yellow

Figure 2.11 Color Codes for Military Symbols

(2) Colors used for military maps. By the fifteenth century, most European maps were carefully colored. Profile drawings of mountains and hills were shown in brown, rivers and lakes in blue, vegetation in green, roads in yellow and special information in red. A look at the legend of a modern map confirms that the use of colors has not changed much over the past several hundred years. To facilitate the identification of features on a map, the topographical and cultural information is usually printed in different colors. These colors may vary from map to map. On a standard large-scale topographic map, the colors used and the features each represent are:

(a) **Black.** Black indicates cultural (man-made) features such as buildings and roads, surveyed spot elevations, and all labels.

(b) **Red-Brown**. The colors red and brown are combined to identify cultural features, all relief features, non-surveyed spot elevations, and elevation such as contour lines on red-light readable maps.

(c) **Blue**. Blue identifies hydrographic or water features such as lakes, swamps, rivers, and drainage.

(d) **Green.** Green identifies vegetation with military significance such as woods, orchards, and vineyards.

(e) **Brown.** Brown identifies all relief features and elevation such as contours on older edition maps and cultivated land on red-light readable maps.

(f) **Red.** Red classifies cultural features, such as populated areas, main roads, and boundaries, on older maps.

(g) **Other**. Occasionally, other colors may be used to show special information. These are indicated in the marginal information as a rule.

2. ORSA Operational Assignments

Figure 2.12 depicts the current structure and location of analysts deployed to Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF).

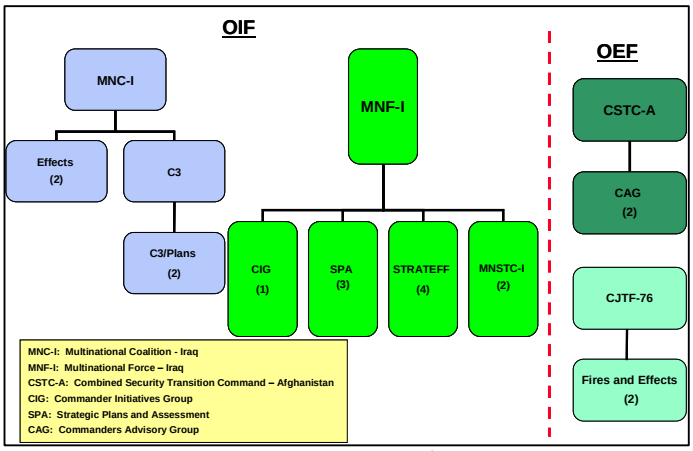

Figure 2.12 Structure and Location of Analysts in OIF and OEF

a. Location: Operation Iraqi Freedom (OIF).

(1) MNF-I
  (a) SPA Assessment (3)
  (b) Strategic Effects Assess (4)
  (c) CIG (1)
  (d) MNSTC-I (2)

(2) MNC-I
  (a) Effects (2)
  (b) C3 Plans (2)

(3) Division (2)

b. Location: Operation Enduring Freedom (OEF).

(1) CSTC-A (CAG) (2)
(2) Division/Corps (2)

c. Duties and Responsibilities.

(1) General. ORSA personnel have the same duties and responsibilities at all levels of command. The only difference is the focus of the analysis. The following bullets highlight the focus at each level of command:

(a) Division: Analysis is focused primarily at the tactical environment with some overlapping of the operational environment.
(b) Corps: Analysis is focused primarily at the operational environment with some overlapping of the tactical and strategic environments.
(c) Echelons above Corps: Analysis is focused primarily at the strategic environment with some overlapping of the operational environment.

(2) Specific. The following highlight some of the more prevalent analytical duties and responsibilities that

ORSA personnel can expect to execute in support of their command:

(a) Assessment: Identify, develop, and analyze metrics to quantify effectiveness of operations conduct in support of obtaining the objectives and effects outlined in the Campaign Plan.

(b) Public Opinion Polls: Develop, administer, and analyze survey results to determine populace attitude and assess current objectives and effects of the campaign plan.

(c) Analysis: Conduct analysis as requested to support decision making process. This analysis consists of providing answers to Requests for Information (RFI) such as trends of different types of attacks and trends of casualty data. This analysis could also focus on resource allocation, determining optimal flow of new technology into theater, or battlespace transition assessment analysis.

3. Joint Forces Reference

As a deployed analyst, you will likely be serving in a Joint Task Force (JTF) Headquarters and operating along side organizations and analysts from other services. In order to be effect you should have a minimum understanding of the structure and capabilities of those other organizations. The following sections give a brief overview and provide resources for further reference.

a. Army.

(1) Combat Maneuver Organization

The US Army currently consists of 10 divisions as well as several independent units. The following order of battle will be realized following the completion of the Army's transformation plan in 2009. Each division will have four ground maneuver brigades (shown here), and will also include at least one aviation brigade as well as a fires brigade and a

service support brigade. Additional brigades can be assigned or attached to a division headquarters based on its mission.

(2) Corps Organization (REF: FM 100-15)

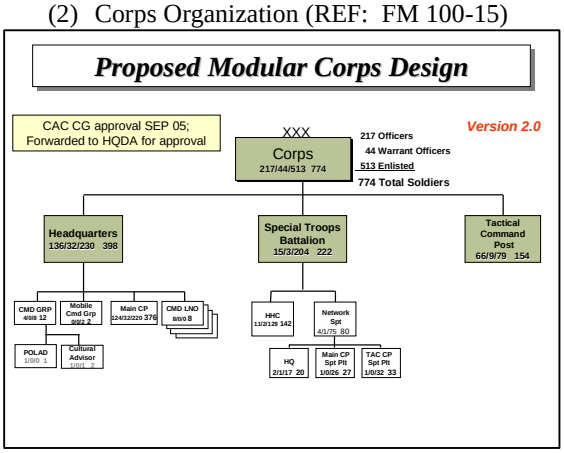

Figure 2.13 Proposed Modular Corps Design

(3) Division Organization (REF: FM 71-100)

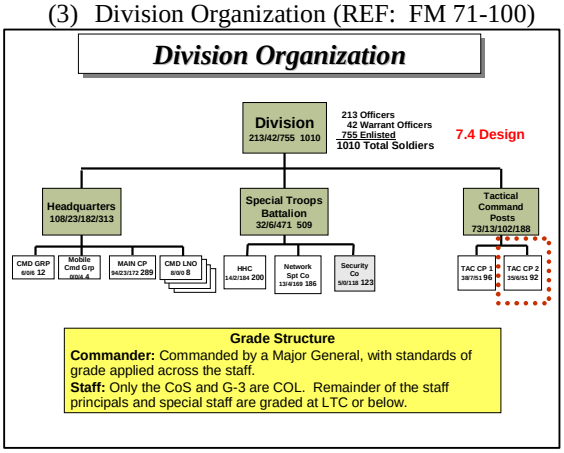

Figure 2.14 Division Organization

(4) BCT (REF: FM 3-90.6)

(a) Heavy

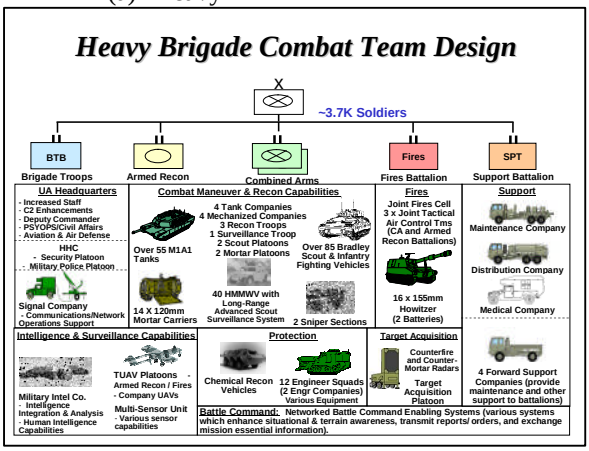

Figure 2.15 Heavy Brigade Combat Team Design

(b) Infantry

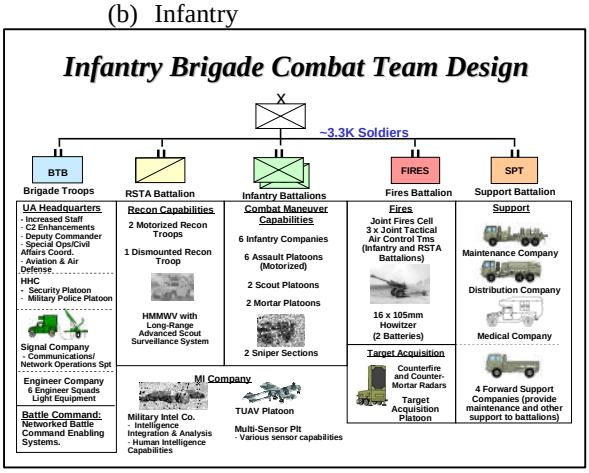

Figure 2.16 Infantry Brigade Combat Team Design

(c) Stryker

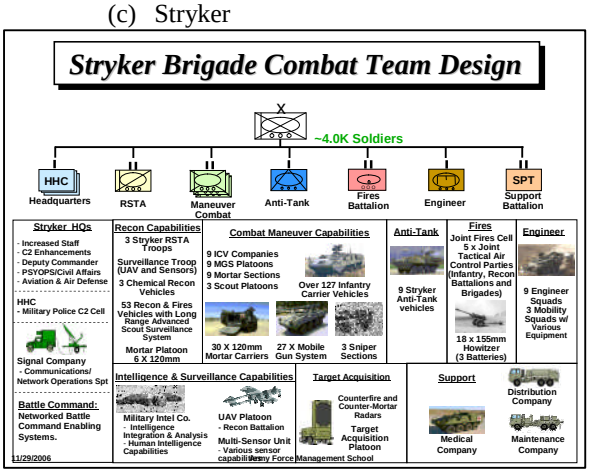

Figure 2.17 Stryker Brigade Combat Team Design

b. Marine (REF: MCRP 5-12D).

(1) MAGTF (Marine Air-Ground Task Force) - The MAGTF is the Marine Corps' principle organization for the conduct of all missions across the range of military operations. MAGTFs are balanced, combined-arms forces with organic ground, aviation, and sustainment elements. They are flexible, task-organized forces that can respond rapidly to a contingency anywhere in the world and are able to conduct a variety of missions. Although organized and equipped to participate as part of naval expeditionary forces, MAGTFs also have the capability to conduct sustained operations ashore. The MAGTF provides a combatant commander or other operational commander with a versatile expeditionary force that is capable of responding to a broad range of crisis and conflict situations. MAGTFs are organized, trained, and equipped to perform missions ranging from humanitarian assistance to peacekeeping to intense combat and can operate in permissive, uncertain, and hostile environments. They may

be shore- or sea-based in support of joint and multinational major operations and/or campaigns. Each MAGTF has four core elements: a CE, a ground combat element (GCE), an aviation combat element (ACE), and a CSS element (CSSE).

(2) MEF (Marine Expeditionary Force) - The MEF is the principal Marine Corps warfighting organization. It is capable of missions across the range of military operations, through amphibious assault and sustained operations ashore in any environment. With appropriate augmentation, the MEF CE is capable of performing as a JTF headquarters.

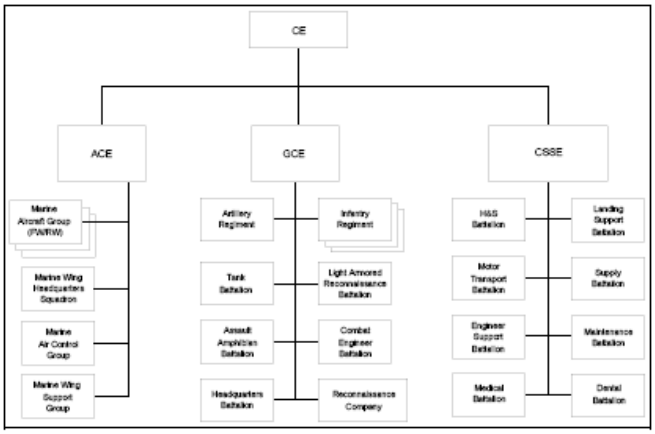

Figure 2.18 Example of MEF Organization

(3) MEF(FWD) - The lead echelon of the MEF, tailored to meet the specific mission, is designated the MEF (forward) (MEF(FWD)) and may be commanded by the MEF commander personally or by a designated commander. The MEF(FWD) prepares for the subsequent arrival of the rest of the MEF or other joint or combined forces. However, the deployment of the MEF(FWD) does not necessarily mean that all the forces of the standing MEF will follow. This would occur only if the entire MEF were required. MEU(SOC) (Marine Expeditionary Unit (Special Operations Capable)) - The MEU (SOC) is the standard forward-deployed Marine expeditionary organization. It is a self-contained operating

force capable of missions of limited scope and duration and as a forward-deployed extension of the Marine expeditionary force. MEUs routinely receive special training before deploying that results in their being designated as “special operations capable.”

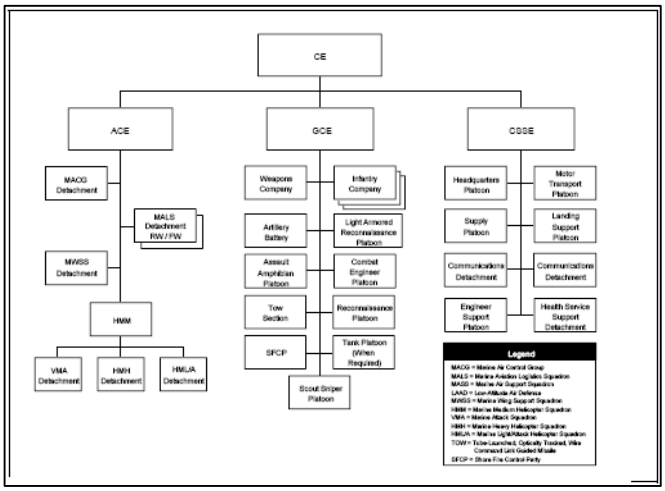

Figure 2.19 Example of a MEU (SOC)

c. Navy (REF: Wikipedia, United States Navy).

(1) Operating Forces - There are nine components to the operating forces of the U.S. Navy: Atlantic Fleet, Pacific Fleet, Naval Forces Central Command, Naval Forces Europe, Naval Network Warfare Command, Navy Reserve, Naval Special Warfare Command, Operational Test and Evaluation Forces, and Military Sealift Command.[13] Fleets in the United States Navy take on the role of force provider; they do not carry out military operations independently, rather they train and maintain naval units that will subsequently be provided to the naval forces component of each Unified Combatant Command. While not widely publicized, groups of ships departing U.S. waters for operational missions gain a Task force type designation, almost always with the Second or Third Fleets. On entry into another numbered fleet's area of

responsibility, they are redesignated as a task group from that fleet. For example, a carrier task group departing the Eastern Seaboard for the Mediterranean might start out as Task Group 20.1; on entry into the Mediterranean, it might become Task Group 60.1. The United States Navy has five active numbered fleets, each led by a Vice Admiral. These five fleets are grouped under Fleet Forces Command (the former Atlantic Fleet), Pacific Fleet, Naval Forces Europe, all led by four-star full Admirals, and Naval Forces Central Command, whose commander is 'double-hatted' as Commander Fifth Fleet.

(2) ATF (Amphibious Task Force) At the most basic level, an amphibious force consists of a Navy element – a group of ships known as an amphibious task force (ATF) – and a landing force. The ATF consists of a mix of amphibious warships, support ships, and perhaps Maritime Prepositioning Force ships that carry equipment and sustainment for Marine forces flying into the theater of operations from overseas. During crisis or combat situations, most amphibious task forces will operate under the protective umbrella of an aircraft carrier battle group, which provides cover for the ATF and support to operations ashore. ATFs can be sized and organized to support a range of different size landing forces. Forward-deployed Amphibious Ready Groups with embarked Marine Expeditionary Units (MEUs) are used for most peacetime presence and small-scale crisis response missions. Three-ship Amphibious Ready Groups – consisting of a large-deck amphibious assault ship (LHD or LHA), and amphibious transport dock (LPD), and a dock landing ship (LSD) – carry the MEU and the helicopters and amphibious assault vehicles that transport Marine combat and support elements ashore. They also support the operations of the MEU's vertical/short take-off and landing aircraft, both helicopter and fixed-wing that provide the MAGTF with integrated air support.

(3) CEG (Convoy Escort Group) – Tasked with protecting military and merchant convoys in transit. Composition depends on the primary threat to the convoy (e.g. air attack, surface or submarine attack).

(4) CVBF (Carrier Battle Force) – Composed of several carriers and their escorts working together under a single commander. It is usually formed by a union of two or more Battle Groups and may easily number over fifteen ships.

(5) CVBG (Carrier Battle Group) - A carrier battle group (CVBG or CARBATGRU) or carrier strike group (CVSG) is a fleet of ships in support of an aircraft carrier. Such groups are primarily used by the United States Navy, which has 12 carrier battle groups scattered across the world. Their existence is an important part of the power projection capability of the United States in that they provide the ability to strike quickly almost anywhere in the world.

(6) URG (Underway Replenishment Group) – A group of supply ships capable of underway replenishment of naval ships at sea. Their mission is to shuttle between port and the group they are supporting.

d. Air Force (Ref: http://www.af.mil/factsheets; Air Force Handbook, 2006; Wikipedia.org).

(1) Wing - The basic unit for generating and employing combat capability is the wing. Composite wings operate more than one kind of aircraft, and may be configured as self-contained units designated for quick air intervention anywhere in the world. Other wings continue to operate a single aircraft type ready to join air campaigns anywhere they are needed. Air base and specialized mission wings such as training, intelligence and test also support the Air Force mission.

(2) Group - A group is a large Air Force formation usually composed of four or more squadrons and the bases from which they operate.

(3) Squadron - A squadron is the basic unit of the Air Force, usually consisting of ten to eighteen aircraft.

(4) Flight - The flight is an air force unit that is smaller than a squadron.

e. SOF (Special Operations Force).

(1) Army (REF: FM 3-05) - The United States Army Special Operations Command (USASOC or ARSOC) is the command charged with overseeing the various Special Operations Forces (SOF) of the United States Army. The command is part of the United States Special Operations Command (USSOCOM); a larger command overseeing all the different SOF Commands of each branch of the U.S. military.

(a) Special Forces - The United States Army Special Forces —also known by the nickname Green Berets or simply Special Forces - is a Special Operations Force of the United States Army trained for unconventional warfare and special operations. U.S. Army Special Forces is divided into five Active Duty Special Forces Groups (SFG) and two National Guard Groups. Each Active Duty SFG has a specific regional focus. The Special Forces soldiers assigned to these groups receive intensive language and cultural training for countries within their regional area of responsibility:

- 1st Special Forces Group - 1st Battalion stationed in Okinawa, the 2nd and 3rd Battalions headquartered at Fort Lewis, Washington. 1st SFG has responsibility for the Pacific.
- 3rd Special Forces Group - Headquartered at Fort Bragg, North Carolina. 3rd SFG has responsibility for all of sub-Saharan Africa except for the eastern Horn of Africa.
- 5th Special Forces Group - Headquartered at Fort Campbell, Kentucky. 5th SFG has responsibility for the Middle East, Persian Gulf, Central Asia and the Horn of Africa (HOA).
- 7th Special Forces Group - Headquartered at Fort Bragg, North Carolina. 7th SFG has responsibility for Latin and Central America as well as the Caribbean (along with 20th SFG).

- 10th Special Forces Group - 1st Battalion stationed near Stuttgart, Germany, and the 2nd and 3rd Battalions are headquartered at Fort Carson, Colorado. 10th SFG has responsibility for Europe, mainly Central and Eastern, the Balkans, Turkey, Israel and Lebanon and northern Africa.
- 19th Special Forces Group - One of the two National Guard groups for the Special Forces. Headquartered in Draper, Utah.
- 20th Special Forces Group - One of the two National Guard groups for the Special Forces. Headquartered in Birmingham, Alabama, under Southern Command

(b) Ranger - The 75th Ranger Regiment, also known as the United States Army Rangers, is a light infantry special operations force of the United States Army Special Operations Command (USASOC); with headquarters in Fort Benning, Georgia. The Regiment is a flexible, highly-trained and rapidly deployable Light Infantry force with specialized skills that enables it to be employed against a variety of conventional and special operations targets. The force specializes in airborne, air assault, Light Infantry and direct action operations, raids, infiltration and exfiltration by air, land or sea, airfield seizure, recovery of personnel and special equipment, and support of general purpose forces (GPF) among others. Each Ranger battalion can deploy anywhere in the world within 18 hours' notice.

(c) SOAR - The 160th Special Operations Aviation Regiment (Airborne) (160th SOAR (A)) is a special operations force of the United States Army that provides helicopter aviation support to general purpose forces and Special Operations Forces. Its missions include attack, assault, and reconnaissance, and are usually conducted at night, at high speeds and low altitudes, on short notice, and in secret. The force is headquartered at Fort Campbell, Kentucky. The 160th SOAR (A) is also known as the Night Stalkers and its motto is Night Stalkers Don't Quit (NSDQ).

(d) Civil Affairs - During war time, the primary mission of Civil Affairs is to minimize civilian interference in military operations. Civil Affairs soldiers are responsible for identifying non-governmental and international organizations operating in the battlespace, handling refugees, civilians on the battlefield, and determining protected targets such as schools, churches/temples/mosques, hospitals, etc. Civil Affairs is the commander's sole link between the US Army and host nation authorities. The soldiers provide general support functional specialty teams which interface and provide expertise to the host nation government. The CAPOC soldiers are particularly suited for this mission since they are reservists with civilian occupations such as law enforcement, engineering, medicine, law, banking, public administration, etc. Civil Affairs Special Operators have been solely responsible for "nation-building" in countries such as Iraq and Afghanistan. Its direct support tactical teams will go out and meet with local officials, conduct assessments, and determine the need for critical infrastructure projects such as roads, schools, power plants, clinics, sewer lines, etc., and check up on the status of the project after construction by a local company has begun.

(e) Psychological Operations - Psychological Operations soldiers provide critical support to the commander by advertising the good work of Civil Affairs soldiers to the local populace via leaflets, radio and television broadcasts, and print publications. They also keep the host nation populace informed of dangers such as minefields. They also conduct broadcast operations during raids and military operations, warning civilians of imminent danger. These special operations soldiers were primarily responsible for keeping the Iraqi and Afghan public informed about their elections, providing directions to polling places via print and broadcast. 'PSYOP' is only used in the host nation country.

(f) Delta Detachment - The 1st Special Forces Operational Detachment-Delta (1st SFOD-D), commonly referred to as Delta within the U.S. Army or as Delta Force by the general public and officially recognized by the Department

of Defense as the Combat Applications Group, is a Special Operations Force (SOF) and an integral element of the Joint Special Operations Command (JSOC). The unit's primary tasks center around counter-terrorism, although it is an extremely versatile group and is fully capable of taking on any number of mission profiles.

(2) Air Force - Air Force Special Operations Command, was established May 22, 1990, with headquarters at Hurlburt Field, Fla. AFSOC is a major command and the Air Force component of U.S. Special Operations Command, a unified command located at MacDill Air Force Base, Fla. AFSOC provides Air Force special operations forces for worldwide deployment and assignment to regional unified commands. The command's SOF are composed of highly trained, rapidly deployable Airmen who are equipped with specialized aircraft. These forces conduct global special operations missions ranging from precision application of firepower, to infiltration, exfiltration, resupply and refueling of SOF operational elements. AFSOC's unique capabilities include airborne radio and television broadcast for psychological operations, as well as combat aviation advisors to provide other governments military expertise for their internal development. The command's special tactics squadrons combine combat controllers, special operations weathermen and para-rescuemen to form versatile SOF teams. AFSOC core tasks are grouped into seven mission areas: shaping the battlefield, information operations, precision engagement, SOF mobility, agile combat support and aerospace interface. AFSOC has approximately 12,900 active-duty, Air Force Reserve, Air National Guard and civilian personnel. The command's active duty and reserve component flying units operate fixed and rotary-wing aircraft, including the CV-22, AC-130H/U, C-130, EC-130, MC-130E/H, MC-130P, and MH-53. The command's forces are organized under one active-duty wing, two reserve wings and three ANG wings, two overseas groups and several direct reporting units. Air Force Special Operations Forces, also at Hurlburt Field, stood up Dec. 13, 2005 to provide worldwide Air Force special operations command and control support to combatant

commanders. AFSOF is designated as the air component's unit of execution to U.S. Special Operations Command. AFSOF will provide a special operations liaison element to regional air operations centers and a forward command

(a) SOW (Special Operations Wing) - The 16th Special Operations Wing, also at Hurlburt Field, is the Air Force's only active-duty special operations wing. The 16th SOW is composed of a variety of specialized aircraft to support special operations worldwide.

(b) SOG (Special Operations Group) - The 352nd Special Operations Group, at Royal Air Force Mildenhall, England, is the Air Force component for Special Operations Command Europe. The 353rd Special Operations Group, at Kadena Air Base, Japan, is the Air Force component for Special Operations Command Pacific. The 720th Special Tactics Group at Hurlburt Field trains, organizes, and equips more than 800 combat controllers, special operations weathermen, and pararescuemen for assignment to special tactics squadrons.

(3) Navy - The major players in U.S. Navy special operations are Navy SEALs and Special Warfare Combatant-craft Crewmen (SWCCs, pronounced “swicks”). The SEALs derive their name from the environments in and from which they can operate: SEa, Air, and Land. As befitting their title, the SEALs are a flexible group of naval Special Forces trained to conduct clandestine warfare in any setting, most often in small-unit actions. They specialize in maritime operations; striking from and returning to the sea. Working in conjunction with the SEALs are the SWCCs, who are trained in small ship and watercraft operations in the Navy. Organized into Special Boat Teams, SWCCs specialize in the insertion and extraction of SEALs in hostile territory, coastal patrol and surveillance, and the boarding and searching of vessels. Navy special operations fall under the jurisdiction of Naval Special Warfare Command, the Navy branch of United States Special Operations Command. Within Naval Special Warfare Command are six operational entities: four Special Warfare

Groups, the Special Warfare Development Group, and the Special Warfare Center. Naval Special Warfare Group ONE and Group TWO each consist of four teams of Navy SEALs and a few Naval Special Warfare (NSW) Units. NSW units are charged with overall command and control and planning of special operations within their geographic jurisdiction. Group THREE is made up of SEAL Delivery Vehicle (SDV) Teams and one Special Boat Team that is shared with Group FOUR. SEALs who are assigned to SDV teams specialize in the use of Swimmer Delivery Vehicles (known as "SEAL Delivery Vehicles" in American service) and Advanced SEAL Delivery Systems (ASDSs). These watercraft are submersibles that are designed to insert SEAL operators underwater, from long distances offshore. Group FOUR is comprised of all of the Navy's Special Boat Teams. The Navy Special Warfare Development Group, also known as Dev Group or DEVGRU, is the United States military's premier Maritime Counter-Terrorism unit. While the Navy confirms the existence of the unit, it merely states that the role of Dev Group is to test, evaluate, and develop technology and maritime, ground and airborne tactics for Navy Special Warfare. No official mention of Counter-Terrorism concerning DEVGRU is made. Though much of the information regarding this unit is classified, it is estimated that the group consists of approximately 200 active operators. The Naval Special Warfare Center, located in Coronado, California, is the main training center for Navy special operations personnel. It is here that SEAL recruits undergo the initial six-month-long Basic Underwater Demolition/SEAL (BUD/S) course. Following three weeks of additional parachute training with the Army, recruits return to Coronado for the 19-week SEAL Qualification Training (SQT), after which they are officially named a SEAL.

CHAPTER III: DATA MANAGEMENT METHODS

1. Introduction

a. Purpose. The purpose of this section is to provide the analyst with an overview of data management methods. The intended objective of this chapter is not to present a "cookbook" of detailed procedures, nor is it to explore abstract, conceptual techniques. Rather, it is intended to promote an analytical approach that is designed to be more responsive to the needs of decision makers at all levels of the Army leadership. Topics covered include a discussion of general data considerations as well as requirements associated with data collection, entry, reporting, and analysis.

b. Data management definition. Data Management is the process of planning, coordinating and controlling an organization's data resources. Key responsibilities associated with data management include data acquisition/collection, data indexing/cataloging/storage, and data verification/validation.

c. Data management goals and objectives. Decisions are seldom based on perfect information. Part of the analyst's job is to discern what information is pertinent and meaningful, and to use this data in the problem solving process. However, lack of appropriate data and inaccurate or invalid data are the source of many fruitless analytical efforts. Many study efforts are based on sound analytical design; however the results of these studies become questionable when the techniques are applied to invalid data. One source of error lies in the unchallenged acceptance of "official" figures. Analysts must challenge sources of information. They must examine all the data upon which the analysis is based. They must determine how it was derived, and must check it for accuracy. It is important to remember that one of the key functions of the data gathering procedure is that of rejecting bad data and inaccurate information. Assuring and maintaining data

integrity is fundamental to the mission and requires a considerable investment of staff time.

2. Data Management Process Overview

a. Data Flow Model. A simple data flow model provides a good starting place for understanding how data handling procedures are carried out. The model identifies five key steps in data flow: acquisition, verification, validation, analysis and dissemination. These steps plus additional procedural details are described in the following sections. Storage, maintenance and security issues apply to all stages of the data flow.

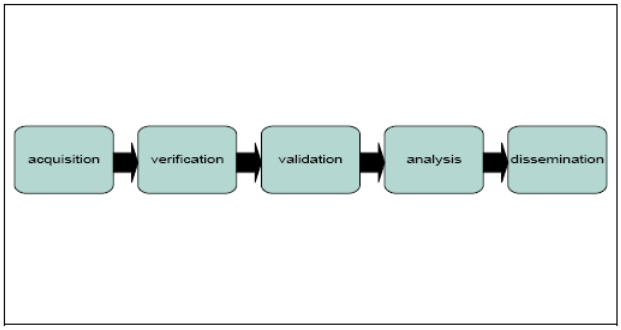

Figure 3.1 Data Flow Model

b. Data Acquisition. The need and ability to acquire and collect data from many internal and external sources is critical to an ORSA but can also be quite complicated. Sometimes it is necessary to collect raw data in the field (i.e. post blast analysis from IED event). In other cases, it is necessary to elicit data from people (i.e. polling/survey data). Data acquisition may also be the direct result of data mining or field studies conducted by the staff. Regardless of how they are collected, data must be validated and filtered. A classic expression that sums up the situation is "Garbage in, garbage out" (GIGO). Therefore, data quality is an extremely important issue.

(1) Certain characteristics are common to all types of data collection activities and center on three main areas:

(a) Data population for measurement (who): The population to be measured must be defined in order to use good statistical analysis methods. Even if the population is generally known, it is still necessary to have a precise definition, because all measurements relate only to the defined population from which they were taken. The specific elements selected from the general population for sampling are called *sampling units*. Sampling units must be unique, easily identifiable, and selectable. For example, if a poll is conducted involving soldiers from multiple units, certain criteria should be captured and associated with the data. Rank, branch, duties and responsibilities should all be captured and assigned to each respective population so that all measurements from that population can be easily identified. An example might be: PV2 John Doe is an Infantry Soldier with the 101st ABN DIV and was stationed in Iraq from JAN05-JAN06. Measurements can easily be associated with this individual, the activities he took part in, etc. The key is to ensure the sampling unit is both discrete (countable) and utilizes standardized and defined terms that are easily recognizable by all users of the data.

(b) Items for measurement (what): After defining the population and the units for sampling, the *specific* items to be measured must be defined and selected. Measured items must have clear definitions, be easily recognizable, have a clearly defined set of observable measurement parameters (qualification standards), and be given a discrete name. For example, with an initial spot report the unit submits to describe enemy activity, a clear description should include (at a minimum) what the friendly forces were doing when the incident occurred (patrol, recon, etc.), where the incident took place (grid location), how many soldiers were involved in the incident, what the incident consisted of (i.e. IED explosion), and what the outcome of the incident was (BDA). Each of these pieces of data should be treated as individual (discrete) pieces of the event to allow further analysis to be conducted on this and future similar events.

(c) Methods of performing the measurement (How): Measurements generally are classified as more *objective* or *subjective*, depending on the amount of human judgment involved. More objective measurements require little or no human judgment and are defined in some kind of physical unit (e.g., grid location, speed of vehicle, number of vehicles in convoy, etc.). Examples of more subjective data might include lessons learned captured from surveys submitted by deploying soldiers. For some aspects of data collection, objective data may ultimately give sensitive, reliable and valid results. However, for other aspects of performance such as evaluating input from soldiers' feedback and assessments, more subjective measurements will probably be necessary. More subjective measurements require that the measured item be evaluated and assigned a score or rating. The result of a subjective evaluation process must also be assessed for measurement validity. It is essential to good data collection that the introduction of outside biases is minimized as much as possible.

(2) High quality data attributes

(a) Sensitivity: Sensitivity means that small gradations or variations in the parameter being measured, such as type of enemy activity or size of friendly/enemy forces, are reflected in some variation in the measurement.

(b) Reliability: Reliability means a lack of random error in the final measurement, which is usually indicated by consistency among items or stability in the measurements over time. Reliability is affected by both sampling and non-sampling errors.

(c) Validity: Validity means that the data accurately measure what they are intended to measure. Data validity depends partly on having adequate sensitivity and reliability of the measures, but even with adequate sensitivity and reliability the data may be measuring something other than what is intended. For example, a poorly worded survey

question may yield results that do not accurately answer the desired question (invalid results). Data validity is weakened or reduced by vague data definitions, insufficient training, casual data collection methods, operator discretion, etc.

(d) Standardization: Standardization means the data collection procedures are uniformly followed. Consistency ensures that data differences do not come from procedural differences. The standardization attribute is very sensitive to non-sampling errors associated with quality of data, collection techniques employed and the stability of established data collection procedures.

(e) Completeness: Completeness means that all the expected data elements, records, observations, etc. are present. Completeness is affected primarily by non-sampling errors. Common causes of incomplete data are: failing to properly enforce the data collection requirements outlined in the standardized data entry report, recording only part of the required information, losing session records before entering data, data collection documents becoming separated, inability to read/scan the data collection form, corrupted files, etc.

(3) Data entry: Data entry is the initial set of operations in which raw source data (survey results, initial spot reports, etc.) are transcribed into a computerized form (i.e., within a database). Data entry commences as soon as data collection is complete. Data entry forms and quality control features are extremely important in minimizing error. Data entry forms should be standardized across all levels of command to ensure consistency in the collected data. These standardized forms should contain logical formats that include discrete data entry choices (i.e. drop down boxes) to reduce transcription errors. Inevitably, the process of transcribing data from field forms to a digital format introduces error. However, standardized data entry forms and quality control features should be enforced at all stages to minimize this error. Data entry forms reduce transcription errors through pick lists and value limits and provide controlled access to the database (i.e. forms are set for data entry only which prevents

accidental deletion or alteration of existing data). Additionally, key fields should also be set to prevent duplicate entry of data. For example, synonymous names (i.e. two or more different names referring to the same unit) are common. Forms also control the sequence of data entry. Through the data entry form, a user should be able to clearly search and retrieve consistent results without worrying about duplicate entries.

c. Data Verification. Irrespective of how the data is acquired, the data is entered or imported into the database and a verification step is required. Data verification immediately follows data entry and involves checking the accuracy of source data. While the goal of data entry is to achieve 100% correct entries, this is rarely accomplished. To minimize transcription errors, a layered approach to data verification should be implemented. Individual records should be checked for quality control throughout the data entry process (i.e. from the unit originating the report all the way up the chain of command). As the ORSA reviewing the entered data, a good rule of thumb is to verify 10% of all records for a certain time period, focusing in on key aspects of the report (event location is correct, event was categorized correctly, etc.). Then, those 10% of records are reviewed and the results of that comparison reported with the data. If errors are found in this review, then the entire data set should be reviewed and verified again. Once the computerized data is verified as accurately reflecting the original field data, these reports should be indexed and cataloged appropriately (i.e. database).

d. Data Validation. Data verification ensures the data was transcribed accurately from the original source field reports. Data validation ensures the data entries are accurate and logical. For example, a report stating the convoy speed was 150mph is illogical and almost certainly incorrect, whether or not it was properly transcribed from field forms. Also, spatial data that was collected within a certain boundary and when viewed in a GIS environment should be within that same boundary. The process of reviewing computerized data for range and logic errors is the validation stage. Certain

components of data validation are built into data entry forms (e.g. range limits). Additional data validation can be accomplished during verification, if the operator is sufficiently knowledgeable about the data. Validation procedures seek to identify generic errors (e.g. missing, mismatched or duplicate records) as well as errors specific to particular items and types of activities. For example, validation of enemy threat data includes database queries and comparison of data among different years. One query detects records with a certain location ID and a certain type of enemy activity (i.e. IED attack). Another query counts the number of IED attacks plots per sample site to assure that all plots were entered. Finally, data is compared to previous years to identify gross differences. The ORSA must assure consistency between field forms and the database by noting how and why any changes were made to the data on the original field forms. Once validation is complete, the data set is archived for storage.

e. Data Organization. The various databases, reports, GIS coverages, etc. used and generated create a large number of files and folders to manage. For example, databases are occasionally stored in two versions of MS Access in order to accommodate data users with different software versions. Further, GIS data are sometimes stored in two projections – one for navigation, the other for use with existing base GIS data. Poor file organization can lead to confusion and data corruption.

f. Data Maintenance and Security. Data sets are rarely static. They often change through additions, corrections, and improvements made following the archival of a data set. There are three main caveats to this process:

(1) Only make changes that improve or update the data while maintaining data integrity.

(2) Once archived, document any changes made to the data set.

(3) Be prepared to recover from mistakes made during editing.

Additionally, secure data archiving is essential for protecting data files from corruption. Version control of records is also a critical piece of the data management process. A good rule is that prior to any major changes of a dataset, a copy is should be made and stored with the appropriate version number. This allows for the tracking of changes over time. With proper controls and communication, versioning ensures that only the most current version is used in any analysis. Versioning of archived data sets should be handled by a logical numbering system with each additional version being assigned a sequentially higher number. Frequent users of the data should also be provided with a copy of the most recent archived version.

g. Data Analysis. The process of data analysis follows, but is not limited to, seven basic steps ("Data Analysis and Decision Making" by Albright, Winston, and Zappe): define the problem, collect and summarize data, formulate a model, verify the model, select one or more suitable decisions, present results, and implement model with updates through time. These steps follow the same general outline of the "Study Process" outlined in Annex C. This will aid in planning the proper course of data analysis-simply put, there are a multitude of statistical tests, optimization methods, and simulation methods but the analyst needs to determine which technique will be appropriate in a given situation. Example tools for analyses include, MS Excel and Access, ARCGIS, SAS, and SPSS. The approach towards data analysis and interpretation of results should be in accordance with scientific standards and appropriate methods and should be evaluated by way of statistical significance as required. Follow-on chapters in this handbook will provide additional details on these types of data analysis.

h. Data Dissemination. Following the appropriate review process, dissemination of data should be made available to all specified users. The data should be in a logical and consistent format for all specified users. Additionally,

guidelines on establishing data ownership should also be outlined. To accomplish this goal, procedures must be developed to ensure that all relevant data collected is quality-checked, analyzed, documented, cataloged, archived, and made available for analysis and management decision-making. Providing well-documented data in a timely manner is especially important to ORSAs since most of our efforts depend on ready access to accurate and complete data. Key aspects include:

(1) Data is easily discoverable and obtainable.

(2) Data that has not yet been subjected to full quality control will not be released.

(3) Distributed data is accompanied by complete metadata that clearly establishes the source and content of the data.

(4) Sensitive data is identified and protected from unauthorized access and inappropriate use. All data and associated information must be assessed to determine their sensitivity. This includes reports, metadata, raw and manipulated spatial and non-spatial data, maps, etc... Classification of data must be clearly identified and follows all rules of use and distribution.

(5) At times, data will need to be exported out of the database to other software applications. An example would be to export data from Access databases for use in other statistical analysis programs (SAS, SPSS, etc.). Other external software requiring data exports will most likely include special application software such as ARCGiS and FalconView for geostatistical analysis. Care should be taken in this export process to ensure data integrity is maintained. The field order [order of variables in the resulting 'flat' file] is most easily controlled while the data are still in the relational database. Field types are typically determined early on, when the database is being designed. To minimize risk of data loss as a result of data type conversion, changes in data types should be

kept to a minimum. ASCII text has the advantage of being almost universally readable by third party applications. Typically, fields are delimited by commas, tabs, or spaces. Text strings are usually enclosed by single or double quotes. ASCII text requires extra steps transferring data between applications and also extra care regarding data format. The preferred alternatives are data exports directly from an Access .mdb file (such as ArcGIS) or link to an .mdb file by way of a data base connection such as OLE DB or ODBC data link (many Windows-based applications).

3. Deployed Analyst Specific Examples.

ORSAs must remain operationally competent across the spectrum of skills resident in joint and combined battle staffs. Having the ability to access and utilize multiple data sources is critical to your primary function of enabling the commander will accurate, relevant and timely information. For example, ORSAs deployed with the Multi-National Force-Iraq (MNF-I) and the Multi-National Corps-Iraq (MNC-I) as well as the Combined Joint Task Forces in Afghanistan utilized multiple data sources to help joint force commanders:

a. Analyze the number and emplacement of medical evacuation helicopter fleets to determine future force-flow requirements.

b. Recommend changes in the emplacement of counter-fire radars to maximize effectiveness in identifying mortar and rocket fires aimed at base camps.

c. Examine the locations of improvised explosive devices (IEDs) to determine possible enemy ammunition caches.

d. Assess counter-IED procedures to reduce attacks on convoy supply routes.

e. Develop metrics and assess plans and operations to adjust future combat operations.

f. Analyze critical nodes and desired effects in the joint effects working group to modify operational plans.

g. Analyze poll results about counterinsurgency operations to gauge the success of efforts to win the hearts and minds of the local population.

h. Examine militia reintegration as a way to begin disarming private armies.

i. Assess the effectiveness of combat and security operations on enemy activity.

4. Bottom Line

Data for decision making comes from a variety of sources, both internal and external. Because the database management system is one of the major components of most decision management support systems, it is important to be familiar with the latest developments in the field. Organizations are recognizing that their data contain a gold mine of information if they can dig it out. Consequently, they are warehousing and mining data for users to obtain information on their own (through a variety of multidimensional analysis tools and new enterprise-wide system architectures), and to establish relationships that were previously unknown (through data mining). New emerging tools, such as Online Analytical Processing (OLAP), a function built into Microsoft Office applications, provide on-the-fly data analysis that will provide invaluable to ORSAs. Additionally, a wide variety of data formats are becoming available as new networked database management systems are developed and deployed. All of these methods can be used by ORSAs to enhance data analysis as well as enable commanders at all levels to make informed decisions.

CHAPTER IV: DATA ANALYSIS TECHNIQUES

1. Introduction

ORSA personnel often face problems where they must make inferences from data in order to recommend certain courses of action, assess a specified activity, and identify trends to name a few byproducts of data analysis. In course of action analysis, ORSA personnel analyze data to provide the commander resource allocation recommendations. Data analysis also underpins operational assessments. For example, data analysis is an objective method for determining if in fact there is a difference between two or more alternatives. Lastly, analysis of enemy and/or friendly activity attempts to identify changes or trends in the operational environment. This chapter presents a methodical approach to analyzing data.

The driving factor behind what technique analysts will use is the question being asked. Based upon the question, the analysts need to determine which technique would provide the most accurate answer to assist the commander in making a decision.

There are several commonly used techniques to analyze data which include statistical analysis, simulation, optimization, network flow models, and geospatial analysis.

a. Purpose. The purpose of this chapter is to assist analysts in identifying when to use different analysis techniques and highlight the techniques that have been utilized by previously deployed analysts.

b. Definition. Data Analysis is the act of transforming data to extract useful information and facilitate conclusions.

2. Data Cleaning

Prior to beginning analysis, the analyst may need to conduct data cleaning and mining of the dataset. The dataset may have missing data, multiple entries of the same event, or

similar events entered using different terminology which require the analyst to clean. Furthermore, the required data to answer the question may be located in "text" fields in which the analyst would need to mine in order to extract the information. Data management techniques are describe in detail in Chapter 2.

3. Statistical Analysis

Accurate analysis necessitates selection of the proper techniques to find out what you want to know. This section will highlight various statistical analysis techniques to include descriptive analysis, correlation, regression, and trending.

a. Descriptive Statistics.

(1) Definition. Descriptive statistics is a method used to summarize and describe important features of the data. Some of these methods are graphical in nature; the construction of histograms and scatter plots are primary examples. Other descriptive methods involve calculation of numerical summary measures, such as means, standard deviations, and correlation coefficients.

(2) Application. Prior to conducting any analysis with pivot tables or other software programs, the analyst should visually inspect the data set. The analyst should graph the data using a scatter-plot, histogram, or time series chart. Along with the graph, the analyst should consider other events that may have an impact on the graphed data. These events could be major operations, elections, transition of battlespace, or significant changes in the political environment (e.g. ratification of constitution, seating of parliament, etc). The visual depiction of the dataset will help determine what technique to use to best answer the requested question.

The graphical depiction or the data along with the calculation of other summary measures will assist the analyst in determining what further technique to employ. In some instances, the summarized measures may provide the answer to the question. For example, leaders may want to know how

a specific event has affected the number of attacks. The analyst can produce a scatter plot of the attack data a set time prior and after a specified event and then calculate the number of attacks over those time periods. Additional time intervals can also be analyzed to provide additional information (e.g. 30 day, 15 day, and 7 day intervals). Figure 3.1 shows a notional example of this technique.

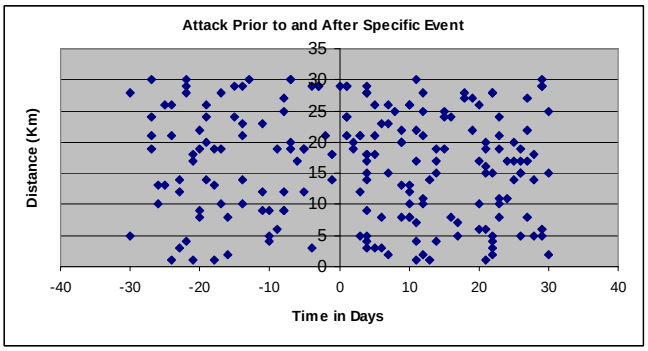

Figure 3.1 Notional Example of Descriptive Statistics

Figure 3.1 uses notional attack data to highlight the application of descriptive statistics to answer a possible question. In this example, a friendly event occurred on a specific data identified as time "zero". The analyst used a scatter plot as well as calculating the number of attacks prior to and after the event to provide insight to the leaders. The number of attacks prior to and after the event was 124 and 76 attacks, respectfully. The analyst could also conduct analysis using the "distance" factor as well to not only determine effects in a temporal sense but also spatially. This information could be used to help assess the success or shortcomings of a specific event.

(3) Reference. Descriptive statistic information can be found in any Statistics book (Devore: Probability and Statistics). There are also many sites on-line that provide background on calculating the numerical measures and developing the graphs. See Annex D for examples of

descriptive statistics used in a project conducted by the Center for Army Analysis (CAA) in support of analysts in Operation Iraqi Freedom.

b. Statistical Techniques. The following are examples of a few statistical techniques used in recent projects conducted in theater or as part of the reachback process.

(1) T-test.

(a) Definition. A t-test is a statistical hypothesis test for two groups in which the test statistic has a t-distribution if the null hypothesis is true. The most frequently used t-tests are 1) a test of the null hypothesis that the means of two normally distributed populations are equal and a test of whether the slope of a regression line differs significantly from 0. If a non-parametric alternative to the t-test is wanted, the usual choices are the Mann-Whitney Test (independent samples) or the Wilcoxon signed-rank test (related samples).

(b) Application. Analysts have mainly used the t-test to determine statistical significance between specific events such as attack types over different periods of time. The t-test could be applied to the example shown in Figure 3.1 to determine if there is any statistical significance between the mean distance of attacks prior to or after a specified friendly event. In this case, the t-test value was .239 for a two-tailed test. The analyst would conclude that there is statistic significance indicating that the mean distance is different for the two time periods.

(c) Reference. Analysts can find the process of conducting a t-test in any statistics book, on numerous internet sites, and in certain software packages to include Excel. Excel has built in commands in the "Analysis Tool Pak" that automatically provides the results for a one-tail or two-tail test.

(2) Regression.

(a) Definition. Regression analysis is used to model relationships between variables and determine the magnitude of those relationships. The models can be used to make predictions. Once the regression model is developed, the analyst can use a t-test and correlation coefficient (see 3.b (3) for further detail) to test the fidelity of the model.

(b) Application. The most commonly used type of regression is the linear regression model. Linear regression determines the relationship between two variables. The first step in this process is to construct a scatter plot of the data. This will show whether there is evidence of a linear relationship between the two variables. Analysts have used this model to determine relationships between attack data (by type of attack) and other major events to include friendly operations (by type of operation), economic development, and transition of battlespace to host nation forces. Based upon the relationship, analysts can use the regression model to assist in estimating or predicting future attack patterns or make recommendations on which type of friendly activities (operations, infrastructure development, economic development, etc) are having a greater impact on the current situation.

(c) Reference. The process to conduct regression analysis can be found in any statistics book, on the internet, and many software packages to include SAS, SPSS, and Stata. Simple regression can be conducted using Excel while Mathematica can handle more complex regression models.

(3) Correlation.

(a) Definition. Correlation measures the association and amount of variation of a dependent variable due to an independent variable. The correlation coefficient indicates the strength and direction of a linear relationship

between two random variables. The best known is the Pearson product-moment correlation coefficient, which is obtained by dividing the covariance of the two variables by the product of their standard deviations. The correlation is 1 in the case of an increasing linear relationship, −1 in the case of a decreasing linear relationship, and some value in between in all other cases, indicating the degree of linear dependence between the variables. The closer the coefficient is to either −1 or 1, the stronger the correlation between the variables. Correlation does not mean causation as other unknowns may impact the relationship. However, correlation does give a good "hint" on the relationship of two variables. Correlation coefficient, as a summary statistic, can not replace the individual examination of the data.

(b) Application. Correlation analysis is used in conjunction with regression analysis to provide greater detail on the relationship between two variables or events. Analysts have used correlation to determine the relationship between time in theater and casualty data, attack data and transfer of battlespace, attack data and friendly operations, and attack data and introduction of new technology.

(c) Reference. Correlation analysis is commonly found in the same section as regression analysis as the correlation coefficient provides greater detail on the relationship of the two variables. Excel has built in commands in the "Analysis Tool Pak" that calculates the correlation coefficient.

(4) Trending.

(a) Definition. Trending is a comparative analysis of a specific event or activity over time.

(b) Application. Analysts have commonly used trend analysis to assist in the assessment process as indicators for specific measures of effectiveness or measures of performance (see Chapter VII for more detail on Effects Based Assessments), in determining the level of enemy activity over

time, and to analyze seasonal trends. Trend analysis is most commonly conducted with the use of Excel. Excel allows the analyst to apply various trend lines by using the "add trendline" feature under the chart menu. The trendline options include: linear, power, exponential, logarithmic, and moving averages. The moving average is a commonly used feature especially when seasonal trends are being analyzed. Figure 3.2 shows the 4 week moving average of notional attack data.

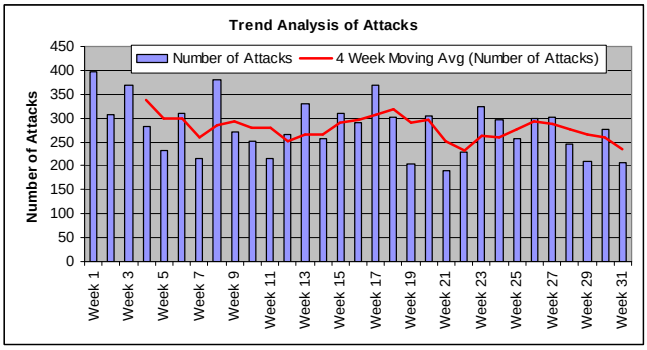

Figure 3.2 Notional Example of Trend Analysis

Figure 3.2 shows the application of a 4 week moving average to notional attack data. An analyst could compare the trend with other significant events (elections, operations, etc) to gain a greater perspective on the associated movement of the trend. A trending over a greater period of time would also allow the analysts to consider seasonal trends in the analysis.

(c) Reference. The best reference for trend analysis would be to review products conducted by analysts in theater. Most analysts have requirements to produce analytical products that contain some level of trend analysis on a recurrent basis.

4. Other Analytical Methods

Many of the following analytical methods may exceed the capability in time, skill level, and software capacity for analysts to conduct in theater. These analytical methods may be more conducive for analysts to request reachback assistance from the various agencies outlined in Chapter 8. Chapter 8 provides details on the capabilities and process of reachback support.

a. Forecasting.

(1) Definition. Forecasting is the process of developing estimates in unknown situations. Forecasting is commonly used when determining a prediction of a specific time series event. Time series methods use historical data as the basis for estimating or forecasting future outcomes.

(2) Application. Forecasting or prediction of future events is becoming more important as we continue the fight in OIF and OEF. Leaders are asking analysts to develop tools and models that can forecast enemy activity both temporally and spatially in order to develop plans to counter this activity. There are many different methods for conducting forecasting. Time series methods include many topics already discussed in this chapter: linear prediction, moving average, extrapolation, and trend estimation.

Some forecasting methods use the assumption that it is possible to identify the underlying factors that might influence the variable that is being forecasted. If the independent variables are understood, projections of the dependent variables can be made and used in the forecast.

Judgmental methods can also be used to assist in forecasting. These methods incorporate intuitive judgments, opinions and probability estimates. Surveys are one of the most commonly used techniques to gain opinion to include in shaping the forecasted estimate.

Another possible method used to assist in forecasting is simulation which will be discussed in the following section.

(3) Reference. The main source of information about forecasting on the internet is the Forecasting Principles site, forecastingprinciples.com. "Forecasting Methods and Applications" by Makridakis, Wheelwright, and Hyndman provides good descriptions and examples of basic forecasting tools, time series decomposition, and simple regression to mention a few of the topics.

b. Simulation.

(1) Definition. Simulation is use of a mathematical model to recreate a situation, often repeatedly, so that the likelihood of various outcomes can be more accurately estimated. Simulation can be used to show the eventual real effects of alternative conditions and courses of action**.** Monte Carlo methods are a widely used class of computational algorithms for simulating the behavior of various physical and mathematical systems, and for other computations. They are distinguished from other simulation methods (such as molecular dynamics) by being stochastic, that is nondeterministic in some manner - usually by using random numbers (or, more often, pseudo-random numbers) - as opposed to deterministic algorithms. Because of the repetition of algorithms and the large number of calculations involved, Monte Carlo is a method suited to calculation using a computer

(2) Application. Analysts have used Monte Carlo methods to assist in developing recommendations for resource allocation. Annex E provides an example of a project conducted for analysts in Operation Enduring Freedom that utilizes Monte Carlo Simulation in helping to develop a recommendation on the number of Medevac assets needed to provide coverage throughout the country. Monte Carlo simulation can also be used to assist in forecasting future activities. The random development of future activities can be

based upon historical data to provide input to the simulation model.

(3) Reference. See Annex E for application of the Monte Carlo Simulation in a real-world project. Analysts can use the random number generator command in Excel to develop a Monte Carlo simulation. Add-ins are also available for Excel designed to conduct simulations such as @Risk. The book by Albright, Winston, and Zappe titled "Data Analysis and Decision Making with Microsoft Excel" includes descriptions of the simulation process and examples.

c. Optimization.

(1) Definition. Optimization (or math programming) is when one seeks to minimize or maximize a real function by systematically choosing the values of real or integer variables from within an allowed set. There are several different methods to conduct optimization to include linear programming, network flow models, and critical path models to mention a few.

(2) Application. Analysts have been asked during the past several years to optimal methods of employing technology, transporting technology and personnel to theater, optimal coverage of specific assets (Medevec, ISR technology, etc), and scheduling problems. To develop an optimization model, the analyst needs to identify the required inputs to include decision variables and constraints. The decision variables are the inputs that can be changed to optimize the objective. The constraints are the conditions that a solution to an optimization problem must satisfy in order to be acceptable. The set of solutions that satisfy all constraints is called the feasible set. One common constraint of all optimization models is "non-negativity" which ensures the decision variables can not be negative. Annexes E, F, and G present different applications of an optimization model used to develop a recommendation for resource allocation, asset utilization, and estimating time of execution for a mission. Analysts can conduct simple optimization problems using the

built in "Solver" of Excel. Excel also allows the analyst to conduct sensitivity analysis to determine how the optimal solution changes as one or more input variables are changed.

(3) Reference. Annexes E, F, and G provide examples on different methods for conducting optimization. The book by Albright, Winston, and Zappe titled "Data Analysis and Decision Making with Microsoft Excel" includes detailed descriptions of optimization models using linear programming.

5. Software Utilization

This section summarizes the use of software packages available to assist in the execution of data analysis. The software packages mentioned here are not all inclusive and analysts are not expected to be experts in the use of each package.

a. Pivot Tables. Pivot tables are a powerful data summarization tool in Excel. Pivot Tables can automatically sort, count, and total data stored in a spreadsheet and create a second table displaying the summarized data.

(1) Pivot tables are useful to quickly create crosstabs in addition to Pivot charts to visually display the resulting information.

(2) Macros: To enhance efficiency the user can automate repetitive actions by creating a macro (a series of recorded actions). Macros can be as basic as simple highlighting or more detailed such as formatting parts of or entirely new worksheets, updating figures in a worksheet or database and then printing it, or charting data as you update it. You can also have macros lead others through the workbooks you create. Macros can be ran, edited, or deleted as the user needs.

(3) Filtering function shows only the data that meets specified criteria. Drop down arrows for each column heading

display the values contained in the column. When a value is not chosen, it remains in the column, but is hidden from view.

b. Excel Add-ins. Excel Add-ins are designed to add capabilities beyond those originally available in Excel.

(1) @Risk is designed for risk analysis and allows users to define probability distributions and run simulations for input and output variables within Excel. @RISK integrates with Excel as an additional toolbar and allows the following functions: select and parameterize probability distributions for spreadsheet cells containing input variables, define cells containing output variables dependent on inputs, run simulations with number of iterations and types of simulation procedures selected by the user, define and format results for output variables, fit distributions to data sets, perform sensitivity tests on effects of changes in input variables on outcomes, perform stress analysis by specifying extreme ranges of input values, use goal-seeking simulations to find best values of inputs for desired results.

(2) Precision Tree is a Decision Analysis Add-In for Excel. It is useful in optimization when dealing with a set of alternatives such as decisions on using few weapons, factoring in decisions at each stage of contracting and development.

(3) Crystal Ball performs Monte Carlo simulations in spreadsheets by automatically calculating thousands of different "what if" cases, saving the inputs and results of each calculation as individual scenarios. Analysis of these scenarios reveals the range of possible outcomes, their probability of occurring, which input has the most effect on the model and where efforts should be focused.

(4) Analysis Took Pak is useful in developing complex statistical analyses. By providing data and parameters for each analysis the tool uses the appropriate statistical or engineering macro functions to calculate and display the results in an output table. Some tools generate charts in addition to output tables. Capabilities include:

ANOVA, Correlation, Covariance, Descriptive statistics, Exponential Smoothing, F-test, t-test, z-test, Regression, Rank and Sampling, among other functions.

c. Complimentary Software

(1) SPSS (Statistical Package for the Social Sciences) is used for statistical analysis in addition to data management and data documentation. Base capabilities allow for: Descriptive statistics, Bivariate statistics (t-test, ANOVA, Correlation, Non-parametric), linear regression, factor analysis, cluster analysis, and Linear Discriminant analysis. Add-on packages increase SPSS capabilities.

(2) Stata is also widely used in the research field. Stata's full range of capabilities include: Data management, Statistical analysis, Graphics, Simulations, Custom programming.

6. Summary

This section has highlighted many different analytical techniques that an analyst can use to execute the requested analysis. Analysts do not have to be experts in every technique but should be knowledgeable on when a technique is appropriate to use. If analysts determine that a problem requires a specific technique and time, skill, or software capacity are an issue, the analyst should request support from reachback agencies to conduct the analysis. Chapter VIII provides details on the reachback process and agencies available to provide support to in theater analysts.

CHAPTER V: REPRESENTATION OF DATA/INFORMATION

1. Introduction

a. Purpose. The purpose of this section is to provide the analyst with best practices in representing data and associated analysis in a clear, accurate and understandable manner.

2. Assumptions

a. Clearly Define Assumptions Used in Analysis. Assumptions are an integral part of any analysis. Analysts need to clearly define and state all assumptions associated with the analysis being conducted. The assumptions can be given by higher headquarters or stated in plans associated with the analysis. The sponsor may also provide assumptions based upon subject matter expertise. These assumptions are usually known up-front and help shape the method of analysis. The analyst may also discover other needed assumptions as the analysis progresses. Assumptions discovered during analysis should be discussed with the sponsor to determine their relevancy or obtain additional data that would eliminate the need to have the assumption. Whether stated up-front or determined during the course of analysis, the analyst needs to ensure all recipients of the final analytic product are knowledgeable of all assumptions by incorporating them in the final presentation or report.

b. State How Assumptions Affect Analysis Results. Another important aspect of assumptions is stating how they affect the analysis and results. Assumptions should only be included if they have an impact on the analysis or results. If the analyst cannot explain the affect, or there is no affect on the results, then the assumption does not need to be stated. The analyst needs to explain the assumptions during the actual presentation or in the notes page of the final product or report. The following are examples of relevant assumptions used in various analytical products conducted in OIF and OEF:

(1) Assumed specific sensor system had line of sight to view significant activities

(2) Attrition rate assumed to be 6.4%

(3) Assume international funds will continue at same level for the next number of years

Assumptions are made to allow the analyst to continue the analysis based upon available information at the time. If additional information or data is made available, the analyst can provide greater fidelity and insight in the final analytical product. Assumptions such as these can assist in the development of a collection plan to acquire specific data to enhance future iterations of the analysis.

3. Caveats

a. State All Caveats. As with assumptions, the analyst must ensure all caveats associated with the data and analysis are clearly stated. Caveats are "warnings" that could include analyst interpretation of data, interpretation of terminology used in the analysis or simply specific caveats associated with the graphical representation of results. The analyst should address all caveats up front to allow the viewer to gain a greater perspective prior to seeing the analysis and results. Caveats associated with specific graphical representation of results show should be included as a text box or bullet on the same slide to ensure that there is no misinterpretation of the results.

b. Caveat Examples. The following are examples of caveats associated with analysis conducted in OIF and OEF:

(1) Population data used was extrapolated from Census conduct in 1975

(2) Up-Armored HMMWV category includes all levels of armoring (Level 1, 2, and 3)

(3) Casualty data includes only Coalition Forces (possible bullet to include on graphical representation slide)

(4) Wording of responses for ANDP 4.0 were different than previous surveys. Binned responses in order to compare with ANDP 1-3 surveys.

Caveats such as these can also inform the sponsor to begin collecting on specific data requirements to enhance future iterations of the analysis.

4. Presenting Results

a. Briefing Techniques. Although this section may seem obvious and common sense to most analysts, it provides some best practices and lessons learned from analysts that have had to brief commanders at all levels.

(1) When presenting a brief on analytical results, the analysts need to first analyze the audience. This includes knowing who the attendees are and what background they may have in operational research. This will assist you in knowing what level of discussion you can have on the analysis techniques used in conducting the project.

(2) In order for the results of a technical study to be accepted at the highest levels, the analyst must be able to communicate technical insights as lay decision options, without getting bogged down in technical detail. Analysts should not assume that the answer to the decision maker's problem is hidden in all the data. The purpose of the briefing is *not* to show the decision maker all the data, and let him find the answer. Analysts must realize that many decision makers are not technical experts. The detailed display of too much technical information contributes additional frustrations to an already complicated decision issue.

(3) All problem solvers must be able to "package" the results of their analytical efforts so that decision makers can understand the insights and implement the

recommendations. Analytical findings must be packaged for decision maker implementation, not for technical fascination.

(4) The purpose or objective of the analysis should be clearly stated at the beginning of the presentation. This may include both a purpose and problem statement. These should be concise statements developed in conjunction with the sponsor.

(5) The presentation should have a logical flow to allow the audience to better understand the purpose, problem, analysis, and results. The bottom line up front (BLUF) should be stated at the beginning of the presentation. This should follow the purpose and problem statement. This allows the audience to understand the end state and results as the analysis is being discussed. Any graphical representation of data or analysis should include a "take away" bullet. The analyst should include a bullet comment on the most important reason for displaying the data or results in this manner. Ensure this bullet stands out by using a color scheme, larger bold text, or some type of symbol to draw the audience's attention to this important fact.

(6) The analyst should create separate visual displays if there is specific information that the audience needs to observe throughout the entire briefing. This is not a common occurrence but an example might include a map of the operational area or a legend of a color scheme that is used throughout the presentation.

(7) The delivery of the brief is just as important as the analysis behind the results. Analysts should rehearse briefs to increase confidence, correct any mistakes, and make any changes to the flow of the presentation. Take time to ensure all technology is operating properly to include knowing how to work the remote. If a remote is not available, have someone else work the slide show presentation for you to limit distractions to you and the audience. You can have the best analytical product but if the delivery is not convincing or

results well presented, then the decision maker could disregard your efforts.

(8) After giving the presentation, re-assess the overall briefing and determine if you achieved your goals. The analyst needs to determine if follow-up presentations or meetings need to occur to ensure all analysis was understood and also determine if there are any follow-on requirements.

b. Stand Alone Slides. The analyst needs to be aware that commanders and staffs at all levels may use only certain slides from a presentation. To ensure there is no misinterpretation of the slides contents there are several steps the analyst should take.

(1) All slides need to have the appropriate classification clearly marked. The analyst should not classify the entire document under one classification but should classify each slide individually. When an entire document is classified together, there is a tendency to over-classify several of the slides. This limits the ability to share information with other coalition members. Furthermore, the process of classifying each individual slide ensures that there is no misinterpretation by other people that may use the presentation or pull certain slides from the presentation.

(2) Slides need to "speak" for themselves. The analyst needs to incorporate word bullets, graphs, tables, or a combination of these to ensure the relevant points of the slide are easily known and recognized. This will limit any misunderstanding or misinterpretation of the results by recipients that are unable to receive a brief from the analyst. It will also limit misinterpretation if other people remove specific slides for use in another presentation (e.g. slide pulled to include in commander's presentation to Secretary of Defense).

(3) When incorporating tables, charts, or graphs from any software package into a presentation in power point, the analyst needs to paste these as pictures. This is

accomplished by using the Edit, Paste Special command in power point. This ensures that others can not manipulate the data or charts in your presentation. Furthermore, the pasting of tables, charts, and graphs as a picture also reduces the size of the presentation and makes it easier to send electronically to the sponsor or other analysts.

c. Charts vice Tables vice Word Bullets Only. In determining the best method to display your results, the analyst needs to consider the audience to be briefed. Display the results in the manner that the audience will best understand the information. This may be command driven as certain commands or sponsors may specify how they want the results displayed. Remember you are conducting the analysis for the "customer" and need to meet their request for presenting the results. If this is not the case, the following are some helpful hints on best practices used in theater.

(1) Use a method that presents information in the most simplistic manner. Do not make slides so complex that the audience has difficulty in understanding the main point of the slide.

(2) Use a combination of graph or tables with accompanying bullets. This allows the analyst to highlight the "take away" of the slide by using bullets to stress this point. Colored text boxes and larger font can help make this point stand out from any other wording on the slide. Using a common color scheme throughout the presentation also allows the audience to quickly recognize the main point of each slide.

(3) Graphical representation of results needs to be properly labeled. The analyst needs to label all aspects of the graph to include: x-axis, y-axis, title, and legend. Data tables need to have all columns and rows clearly defined. Another good practice is to include the data source with all graphs and tables. This allows the audience to know the origin of the data incase follow-on analysis needs to occur to validate your findings.

(4) A common question being asked in theater is "what is the trend associated with X"? Trends may be stated with simple wording such as "attacks have increased for the past 6 months" or "the trend indicates a decrease in casualties over the past three quarters". However, the analyst may want to stress or visually depict the trends by using trend lines within a graph. When using trend lines, the analyst needs to ensure the most appropriate trend line is chosen and to also use word bullets to explain the trend of a specific graph. The most commonly used trend lines are the linear and moving average trend lines from Microsoft Excel. The linear trend line displays an increase or decrease in the graphical representation of the data. The moving trend application allows the analyst to set the number of time periods to use in the moving average (e.g. 4 weeks, 6 months, etc). The type of time period, weeks or months, is based upon the data set. This trend assists in the display of periods of increase or decrease but also helps with the identification of seasonal trends. Microsoft Excel and other software packages also have other types of trend lines that are not as commonly used such as polynomial, exponential, logarithmic, and power. Analysts may want to consider using one of these types of trend lines depending upon the type of problem being analyzed and the data set.

(5) Trend lines are a common technique used by analysts in theater to assist in the explanation of data and to highlight specific areas of interest. However, the analyst needs to make sure the sponsor is aware that forecasting should not be accomplished based upon these type of trend lines. For example, a linear trend line will only lead to one of two possible forecasts, future increase or decrease, depending upon the slope of the linear trend line fitted to the data set. The moving average may assist in determining the "expected" number of incidents that may occur in the future but is not a forecasting tool. For example, if enough data exists to observe several seasonal occurrences the analyst may be able to state an estimated number of incidents expected to occur in the same seasonal time frame. However, this assumes that the future will be similar to that of the past and there are many

other factors that need to be considered when trying to forecast any future occurrence of incidents.

(6) During presentations, analysts need to simplify mathematical concepts behind analysis depending upon the audience. Ensure all mathematical concepts are kept simple enough for the audience to understand but be prepared to provide a greater explanation if the question is asked. A common practice is to place mathematical concept slides in back-up for reference and to quickly address if questions are asked.

d. Graphical Display of Results and Information. Often the display of results and information is more powerful than the technical analysis behind them. The analyst should take extra time to ensure the main points are not overlooked by the audience based upon the manner in which the results and information is displayed. The following are some helpful hints in displaying results.

(1) Many briefers try to improve graphics by adding color. Adding color can make visuals more appealing; however, the indiscriminate use of color can add distractions to an otherwise effective graphic. Use a specific color for the critical points or "take-a-ways" which must stand out and demand audience attention. The analyst needs to limit the number of colors used in each graphic and ensure the choice of colors is consistent from visual to visual throughout the entire presentation. Each graphic need to contain a detailed legend to inform the audience of each color representation.

(2) After completing the analysis, the analyst needs to determine the type of graphic which best communicates the results and main "take-a-way" points. There are several different types of charts to use to convey the results to include: text charts, tables, line charts, surface charts, vertical bar or column charts, and pie charts.

(a) Text charts are the easiest type of graphic to prepare. Analysts need to remember that words or bullets are

not visuals. Pictures, clouds, and arrows used in conjunction with words can create visual effects to better communicate the information or results. Text charts are effective for introducing topics to include methods used in the analysis and for summarizing important ideas or results. Text charts should be concise as possible and it is best to use bullets rather than entire sentences or paragraphs of text.

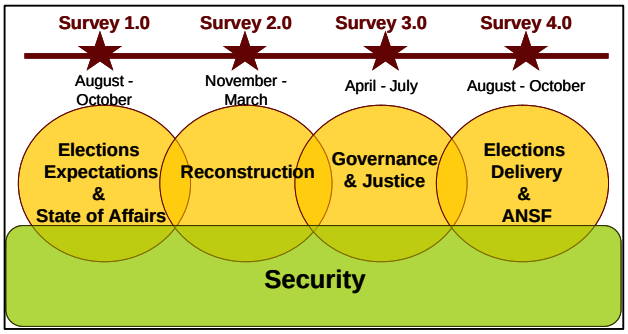

Figure 5.1 Example of Text Chart

Figure 5.1 shows a text chart used to display the survey model of the Afghan National Development Poll.

(b) Tables are used to display raw data or analyzed results. It is difficult to make comparisons or identify trends while looking at numbers in a table. Usually a different type of graphic is more suitable for communicating the results. Tables can be used in conjunction with other graphics if the exact numbers are relevant to the "take-a-way" you are trying to achieve on a particular slide. The important aspect to remember when using tables is ensuring the contents of all columns and rows are clearly annotated.

Tables show specific data.

Annual spending ($B)

	FY '65	'70	'75	'80	'85
Procurement & RDTE	7.6	9.0	10.8	13.4	19.0
Personnel costs	9.1	11.3	13.8	19.5	26.5
other	4.9	5.8	6.7	8.2	10.8

Figure 5.2 Example of Table Chart

(c) Line or curve charts are used effectively to show trends and time series data. This chart can show multiple lines on a single graph but ensure each line is clearly distinguishable from the others using colors or different patterns of lines (solid, dashed, etc). A legend should be used to identify the representation of colors or patterns used for each line.

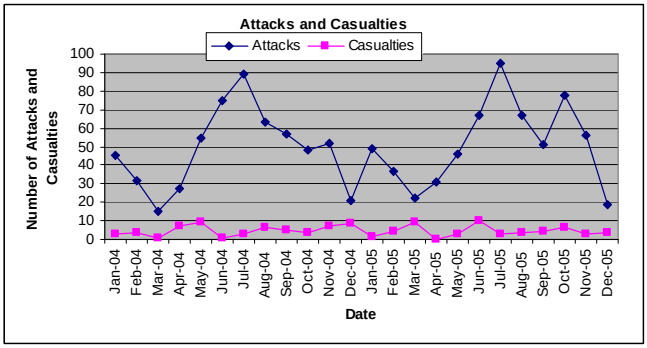

Figure 5.3 Notional Example of Line Chart

Figure 5.3 uses notional attack and casualty data to provide an example of the line chart. The chart defines the x-axis, y-axis, and gives a legend to specify the representation of each line. The analyst would want to provide greater detail in the title to

specify the exact category of this data (coalition forces, civilians, host nation, etc).

(d) Surface charts are simply a single line chart with the area shaded under the line. The shading emphasizes the size of the total amount rather than the differences or changes in the amounts.

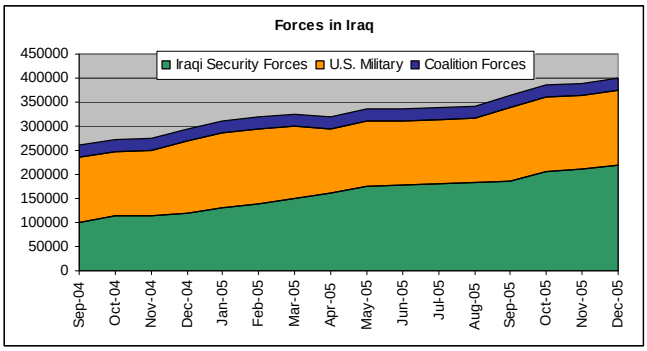

Figure 5.4 Example of Surface Chart

Figure 5.4 uses data from the Iraqi Security Force Update conducted by MNF-I to illustrate the use of the surface chart.

(e) Vertical bar or column charts are used to compare data for the same item at specific time intervals. The height of each chart is used to represent each respective quantity and how it varies across the different time intervals. These time intervals need to be consistent across the entire graph. Excel allows the analyst to select different variations of this type of chart to include stack column chart, percentage column chart, or just graphing multiple categories across the same intervals of time that would be displayed as different colored columns. A legend needs to be included in the graphic when using a column chart with multiple categories.

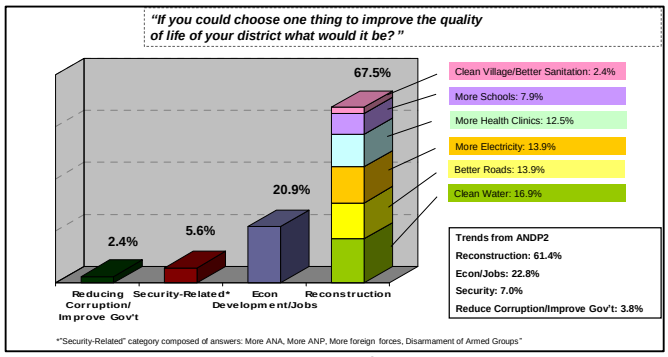

Figure 5.5 Example of Column Chart

Figure 5.5 shows an example of a column chart from the results of the Afghan National Development Poll 4.0. The chart displays the responses to the questions of "If you could choose one thing to improve the quality of life of your district what would it be?"

(f) Pie charts show a composite whole and the proportion that each component part represents. The analyst needs to label each "slice" of the pie to allow easier comparison between the different slices. Excel also allows the user to plot the percentage of each slice along with the label. Again, a legend should be incorporated into the graphic to explain the color code of each separate slice.

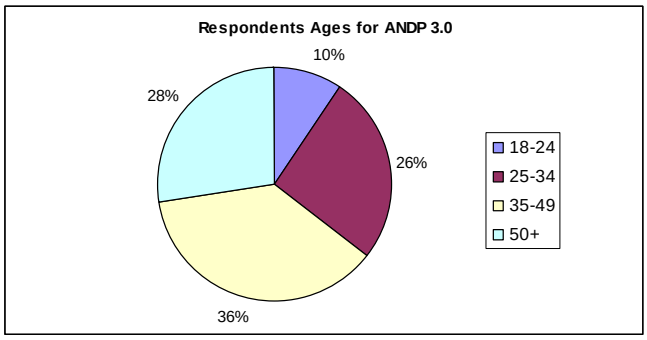

Figure 5.6 Example of Pie Chart

Figure 5.6 shows a pie chart developed in displaying one of the demographic categories from the Afghan National Development Poll. This chart shows the percent of respondents in each age category.

(3) Geospatial analysis is a powerful tool that compliments other types of analysis. There are several geospatial software packages being used by analysts to include: ARCGIS, Falconview, and WEBTAS. These tools allow the analyst to plot data in order to obtain a spatial relationship between incidents. They also have the capability to plot densities and conduct clustering of specific incidents. WEBTAS allows the analyst to also create a "video" of incidents. The user specifies the type of incident to plot spatially and then states the time frame for the icon to remain on the screen. This allows the analyst to view the change in incident pattern both spatially and over time. This is a difficult aspect to include in a presentation but is very useful in the analysis.

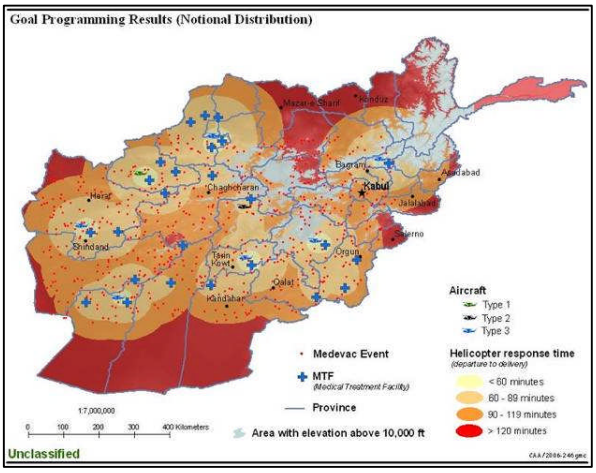

Figure 5.7 Notional Geospatial Representation

Figure 5.7 shows notional MEDEVAC event data and helicopter response time created with ARCGIS. The shading

represents the various response times and the red dots represent the notational MEDEVAC events. This is an example of analysis conducted for forces in Afghanistan.

(4) Other Summary Project Charts. Many analytical agencies use various types of charts to summarize projects being conducted. The "Quad" chart is the most commonly used type. This chart breaks a slide into 4 sections that usually consist of the purpose (problem statement) of the analysis, methods, timeline, and results (insights at the present time). The analyst can adjust these sections to fit there specific project but is a quick way to present a summarization of the work being conducted. The analyst can also provide this type of chart to other analysts or analytical agencies to quickly share work being conducted in theater or by a reach-back agency. The analyst can also amend the "Quad" chart as the situation requires and use a "Tri" or "Bi" chart.

Another use of the "Quad" chart is to show relationships. This type of chart is often used in the assessment process to highlight relationships between different indicators and measures of effectiveness (MOE). These indicators are used to determine an increase or decrease in a specific measure of effectiveness (see Chapter VII: Effects Based Assessments for more details).

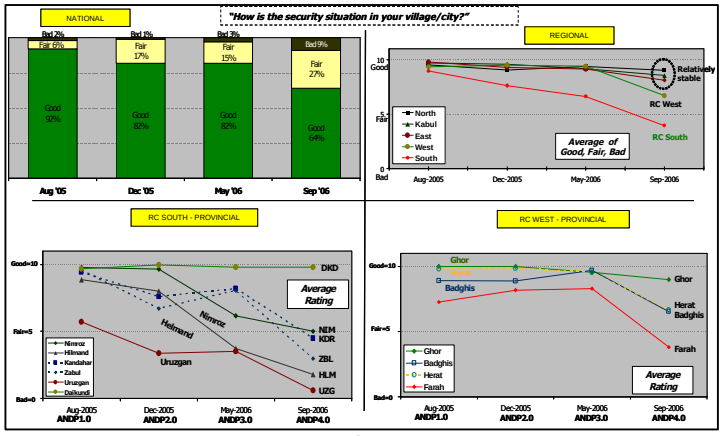

Figure 5.8 Example of Summary Quad-Chart

Figure 5.8 shows a quad-chart used to summarize and highlight trends on a specific question from the Afghan National Development Poll. The same question was asked across all four surveys, "How is the security situation in your village/city?" This information feed indicators and measures of effectiveness to determine if desired effects were being achieved within several objectives of the campaign plan.

CHAPTER VI: SURVEY DEVELOPMENT AND ANALYSIS

1. Purpose of Using Surveys

a. General. During the Global War on Terrorism, the United States military has been intimately involved in all aspects of nation building. In the process of nation building, the populace is always considered the center of gravity. In order to succeed, command decisions need to be made to address, persuade, and change the populace perceptions of key aspects and focus areas of the nation building process. The key aspects and focus areas include as a minimum: reconstruction, governance, security, and justice. Surveys play an integral role in determining the populace perception on each of these aspects. The results of the survey allow the command to conduct assessments and develop action plans to address the populace concerns or ensure positive areas are maintained.

Surveys are also used by commands to gather information on Tactics, Techniques, and Procedures (TTPs) utilized by our own forces. These surveys are used to make appropriate changes or develop new TTPs as the situation requires.

This section will address the importance of using surveys in the assessment process and survey development, fielding, and analysis.

b. Assessment. Deployed analysts have played a major role in the assessment process. This process will be discussed in detail in chapter 6: Effects Based Assessments. In general, the process begins with the development of the Campaign Plan which outlines ways and means of achieving the desired objectives and end states of various focus areas. Assessment metrics are developed to provide a measurable way of determining if objectives are being accomplished. Often the assessment metrics: effects, measures of effectiveness (MOE), measures of performance (MOP), and indicators, are subjective in nature. Figure 6.1 gives some examples of subjective metrics:

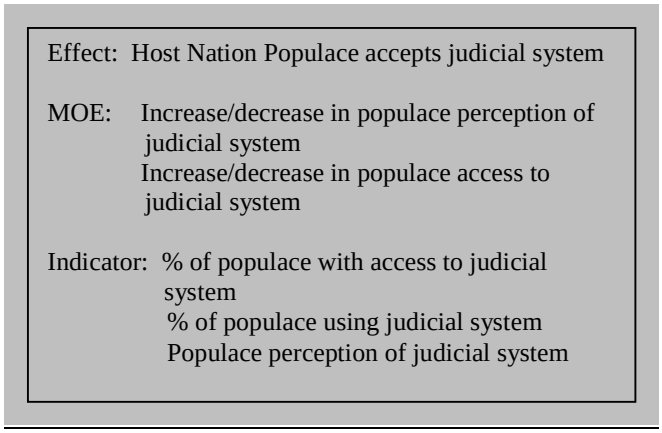

Figure 6.1 Samples of Subjective Assessment Metrics

Analysts can submit data collection requests to obtain data to help assess these subjective metrics. One such request may be asking Staff Judge Advocate to collect on the number of people using the judicial system, number of courts established, and number of judges trained to mention a sample of some desired metrics that could be used to assess the sample shown above. This data although helpful does not allow a true assessment of whether the desired effect is being achieved. The required data to assess subjective metrics is most easily obtained from conducting surveys. Surveys can be constructed to provide data that directly supports the measurement and assessment of the subjective metrics. Figure 5.2 highlights some examples of questions used in Afghanistan to obtain populace perceptions on specific areas to assist the assessment of several subjective metrics:

How happy or unhappy are you with the reconstruction in your village?

How is the security situation in your village or city?

In the future do you think the life condition will improve for your family?

Do you have access to a courthouse?

Have you used the courthouse/judicial system in the last year?

Figure 6.2 Sample Questions from Afghan Survey

The surveys provide a means to measure and assess the subjective metrics and also provide an additional data point for other metrics as well. Survey results not only play a significant role in the assessment process but also in the development of action plans and tasks.

c. Development of Action Plans. Action plans and tasks are mainly developed upon completion of the assessment process but could also evolve based upon analysis of the survey results. The results of the survey analysis are used by the commanders and staff members to make decisions on the allocation of resources. These resources include the Commanders Emergency Response Program (CERP), USAID projects, and force structure. Decision makers use the survey results as one data point in determining the best allocation of resources to maintain successes or improve on areas identified as a shortfall. This may include the adjustment of current action plans or identification of new plans to achieve desired effects or positively change the populace perceptions. For example, analysts provided reconstruction related results to Combined Forces Command – Afghanistan (CFC-A), CJ7 and USAID that were incorporated into future planning of projects to meet the needs of the people.

2. Survey Development Process

a. Develop Survey Model. The initial model concept needs to be developed prior to the contracting phase to ensure the scope of the survey is included in the contract. This scope may include number of surveys, time period for surveying to be conducted, number of questions, and type of report and/or analysis to be completed by contracted agency to mention some of the more important factors. Once the contract is finalized, the analyst can further refine the survey model. This refinement includes the identification of specific areas of focus based upon the commander's Campaign Plan and the assessment metrics developed to measure the success or shortcomings of this plan.

In determining the best time to conduct the surveys and the primary focus area(s) for each survey, one should consider significant events that may occur during the span of the survey contract to include: elections, major operations, significant political events (seating of parliament, ratification of constitution, etc.), or any significant change in force posture. By aligning the surveys with the key events, the surveys can provide greater insight of the specific focus areas. Figure 5.3 shows the model for the Afghan National Development Poll conducted in Afghanistan from June 2005 – November 2006. The model incorporated several focus areas from the Campaign Plan to include: security, reconstruction, governance, justice, democracy, and the Afghan National Security Forces (ANSF) that consist of the Afghan National Army (ANA) and the Afghan National Police (ANP).

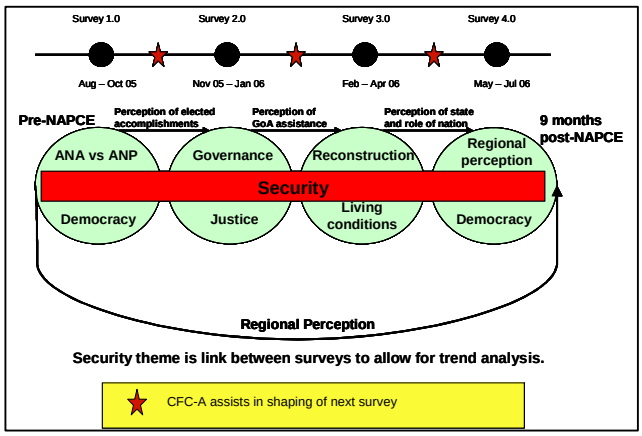

Figure 6.3 Afghan National Development Poll (ANDP) Model

The timeline for the model was driven by the National Assembly and Provincial Council Elections (NAPCE) held in September 2005. The first survey (ANDP 1.0) was conducted prior to the NAPCE to obtain pre-election perceptions. The follow-on surveys were then used to obtain perceptions on the deliverables of the Government of Afghanistan. This is just one example of how to incorporate the focus areas and establish a timeline for the surveys based upon significant events occurring within the country.

b. Determine Methods of Surveying. There are many different methods in which to conduct a survey and analysts may want to fall back on the expertise of the contracted agency to assist in determining the best method based upon the purpose of the survey. However, the most important aspect is to remove any bias associated with the surveying process to the utmost extent. Furthermore, analysts should be knowledgeable on the process of selecting various methods in order to ensure the contracted agency is using the best method for the specific survey. Different methods may be used depending upon the type of survey being conducted or the questions being asked.

(1) Demographics. There are several demographic factors that the analyst needs to consider in developing the survey method. These factors include gender, ethnicity, religion, and rural versus urban. The analyst needs to determine the desired breakdown for each factor if important and ensure to take into consideration statistical significance of sample as this will affect analysis of survey results. For example, one may desire an 80/20 rural versus urban breakdown but if only 100 questions are being asked in a specific province then the 20 responses from the urban center will not provide an 'n' large enough for statistical significance. Once the demographic factors have been determined, the analyst should attempt to keep the factors the same throughout the entire survey process. This would allow comparison across multiple surveys to be conducted without complex translations due to varying demographics. However, analysts should not hesitate to change the demographic factors if it would improve the statistical analysis of future endeavors.

(2) Random Sampling. In order to limit the bias associated with surveys, random sampling needs to occur at every level of the survey process, from the selection of towns/cities to the actual person being interviewed. In certain countries, one may not be able to remove bias for the selection of urban areas as many provinces within a specific country may only have one large urban area. For the rural towns or villages, the method should use a random sample of all possible towns or villages within a specific province. The interviewer should be given the random list and proceed to conduct the interviewing process based upon this list. The only deviation from the random list of rural towns or villages should occur due to security reasons. The interviewer should make every effort to adhere to the provided random listing.

(a) Once the random villages, towns, or cities have been identified, there needs to be a process to select households within those areas to conduct the survey. One method to remove bias of the household selection is to use a prominent feature within the village, town, or city such as a

mosque, government building, or police station. The interviewer would then proceed in a lazy "S" pattern from this prominent feature. The interviewer would conduct interviews of households at a pre-determined interval such as every fifth house. This interval could be determined by estimating the number of households in a specific area of the town and dividing by the number of interviews that will be conducted for this town. For example, the town has 200 households north of the prominent feature (mosque) and the interviewer will conduct 20 interviews. As a result, the interval to determine which household to interview would be every tenth house. The analyst needs to request specific details of how the survey agency plans on conducting the household selection. The following is an example used by the survey agency in Afghanistan:

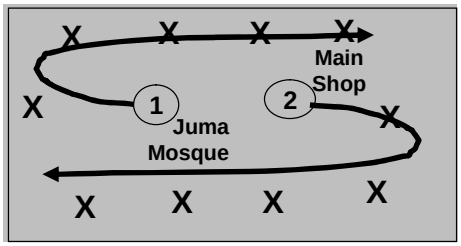

Figure 6.4 Example of Household Selection Method

In this process, the interviewer chose two prominent features within a village, town, or city and then proceeded to select every fifth household in the specified lazy "S" pattern.

(b) With the method of selecting a household established, the next step is to determine the method of choosing the member of the household to be the interviewee. To remove bias with this selection, one can use a coin toss to determine whether a male or female is chosen. Another coin toss could determine the age selection of the interviewee. For example, heads would require a person of the household over 35 be the interviewee and tails would require a person under 35. One must consider the desired male/female demographic breakdown for the entire survey process in doing this type of

process. Another possible selection method for the household member is to use the "Kish Grid". The Kish Grid is shown below:

شماره مصاحبه	تعداد اعضای دکور واندات خانواده (اضافه از عمر 18 سال)								
	2	3	4	5	6	7	8	9	10
1	1	2	1	5	6	4	8	1	10
2	2	1	2	4	6	3	6	5	4
3	1	3	3	3	2	7	4	2	3
4	2	2	4	2	5	3	5	9	6
5	2	1	2	1	4	6	3	1	8
6	1	3	3	3	2	4	6	6	1
7	2	3	4	5	1	5	2	8	6
8	1	2	1	1	2	3	3	4	3
9	1	1	3	4	4	1	4	5	2
10	2	3	4	2	6	1	1	3	2

Figure 6.5 Kish Grid

The vertical axis of the Kish Grid represents the interview number for that day and the horizontal axis is the number of people in a household over 18 years of age. The interviewer would place the household member's names in a list and then would use the Kish Grid to determine which member would be interviewed. For example, if this was interview number 5 and the household had 7 members over the age of 18, the Kish Grid would require the interview be conducted with the sixth family member on the list of names. Another selection method is to interview the male or female head of the household. One would alternate between male and female with each house selected. This method ensures that the desired demographic breakdown for gender is obtained without having to adjust the method of selection.

The key to choosing the most advantageous method for a particular survey is the process that reduces the bias the most.

(3) Type of Survey Techniques. There are several different techniques in which to conduct a survey. The most commonly used method is referred to as an opinion poll. This consists of interviewing individual people on various focus

areas. The questions are all predetermined and are asked in the same manner and order by all people conducting the interviews. The questions have lists of possible responses and may be prompted or unprompted by the interviewer. This aspect will be discussed further in paragraph 2c. Other possible means of conducting a survey are having a sensing session or town hall meeting. These methods usually have predetermined topics and/or questions to assist in promoting discussion. A random selection of city or village residents is selected to attend in order to gain their perspective on certain issues. These types of meetings provide valuable information that can assist the assessment process. However, the unstructured process and open discussions could lead disparate data sets from several meetings held throughout the country. The analyst would need to conduct significant post processing of the data to conduct comparative analysis across the various regions or provinces in which the town hall meetings or sensing sessions were held. More importantly, these types of sessions/meetings may not allow all attendees to voice their opinions or beliefs. The meetings may be dominated by certain members of the meeting and could also influence the comments by others. Furthermore, people may not express their true opinions in this public atmosphere.

c. Develop Survey Questionnaire. The development of the questionnaire can be the most time consuming process. However, if all members of the team are reminded to keep to the developed model then this process can be completed efficiently and with great success.

(1) The primary purpose of conducting surveys is to assist in the assessment process of the Campaign Plan or other similar plans. As a result, the questionnaire needs to be developed based upon the assessment metrics of the specific focus area(s) for that survey. The analyst needs to determine which metrics can be better assessed using results of a survey and then develop questions to obtain this information. Often the data to assess these metrics has already been identified as needing to be collected from a survey during the metric development phase. This makes the identification easier but

the analyst still needs to word the questions correctly to ensure the data provides insight to the particular metric.

(2) The analyst needs to incorporate staff members into the question development process. This may be conducted utilizing a working group concept or just an adjunct meeting. The working group should include as a minimum, the staff members that have a vested interest in the specific focus area(s) of the survey. The staff members are the subject matter experts on the different focus area(s) and are often responsible for providing input for assessments or the actual assessment for objectives and effects for a specific area. Brain storming sessions can be used to develop questions and then the working group can prioritize which questions should be included in the survey.

(3) The analyst must make use of the expertise of the contracted agency conducting the survey. This expertise consists of the development of questions, wording of questions, construction of questions to include various types, and often a greater understanding of the cultural considerations. Based upon the developed model and guidance from the analyst, the contracted agency can take the focus areas and conduct parallel development of questions. These questions can then be compared to those developed by the staff working group and integrated into the prioritization process. The questions developed by the working group should also be shared and discussed with the contracted agency. The parallel development of questions will allow for a wide range of questions from a military and civilian perspective.

The contracted agency can also provide their expertise on the type of question that would be appropriate for each topic. Some examples of different types of questions include: rank the following from 1 to 10, "If yes" or "If no", single versus multiple response, and prompted versus unprompted response. Analyst need to fall back on the advice and experience of the contracted agency on the construction of questions. The contracted agency has the experience to know

which type of question would provide the greatest insight on a particular focus area.

Cultural considerations also play a factor in the type of question to include and how the question should be worded. The contracted agency usually employs host nation members or will hire them to assist with any cultural issues. The manner in which a question is worded could be the difference between getting a majority of "Don't Know" responses and responses that can provide insight to a certain issue. For example, the Afghan National Development Polls used the word "village" in the first three surveys on several different questions. The response from a majority of females was "Don't Know". During ANDP 4.0, a member of the contracted survey company recommended to use the word "Mantaqa" instead of the straight translated word for "village". The Afghan translation of "Mantaqa" is the local area around your house. The results were a significantly reduced "Don't Know" response by females for the questions using this different wording.

d. Survey Fielding Process. Once the questionnaire is finalized it is highly recommended that a field test be conducted for the survey prior to the actual field work.

(1) The field test will shed light on the understandability of the questions, determine if any cultural issues are present, observe questions that provide no insight (eg. 100% of field test respondents answered "Don't Know" for a specific question), and allows the team to adjust, delete or add questions to the survey based upon the results of the field test.

(2) Analysts are highly encouraged to observe and monitor the training of the interviewers. This gives you a greater perspective on the cultural issues and process of constructing a survey questionnaire. Furthermore, if the mission and security situation allows the analyst should attempt to monitor field work to ensure methods are being conducted as prescribed and also allows for the additional collection of information and intelligence. The analyst needs

to consider the sensitivity associated with observing the training or monitoring field work prior to conducting either one. The association with any group assisting the nation building process or coalition forces may put the survey company's employees at risk.

3. Survey Analysis

a. Database. Analyst should discuss software requirements with the contracted survey agency during the initial phase of the survey development. This will allow the analyst to acquire additional needed software during the development and field work time frame. The primary software needed for survey analysis is Microsoft Excel and SPSS. However, the software may be company specific so be sure to address this issue early in the process. For example, the contracted survey company in Afghanistan used SPSS but the analyst did not have that software so analysis was delayed until the software was obtained.

Once the data has been received, the analyst may have to do some additional post processing of the data. This post processing usually consists of changing numeric data fields into recognizable responses and the possible addition of operational data that was not available to the contracting agency for further detailed analysis. For example, the analyst may change the numeric entry for provinces or ethnicity to preclude from having to reference the variable definition of a software program. Furthermore, the analyst may add in the provinces under operational control of host nation forces and the number of host nation forces in each province or district.

b. Basic Representation of Survey Questions. Once the data has been received and post processed, the analyst can begin the analysis. Requests for information (RFI) from the staff or command may dictate the type of analysis to conduct first but it is highly recommended to provide basic graphical representation of the responses to each question. This can be done on a national or provincial level. Figure 6.6 shows the national response to the question "How is the security in your

village/city?" from the third Afghan National Development Poll survey.

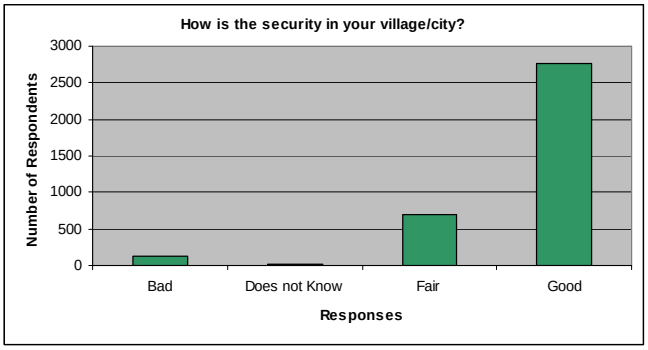

Figure 6.6 Basic Graphical Representation of National Response

This basic graphical representation gives an overview of the results and may identify specific questions or areas that the analyst may want to focus more detailed analysis. The more detailed analysis could consist of analyzing the responses for specific questions at the district and village level to provide greater fidelity and insight to the issues at hand. From the graphical depiction of the national level perspective on security in the respondent's village or city, the analyst may decide to further analyze the "bad" responses to determine if the majority of "bad" responses came from one province or district. Another method to provide more detailed analysis is using cross-tabbing or correlation of different questions.

c. Crosstab/Correlation Analysis. Cross-tabbing or correlation is the process of determining relationships between two or more factors. The analyst may want to determine the responses of a particular question in the survey based upon the response of a separate question. For example, an analyst may desire to know the percent of respondents that stated they did not trust the national police as compared to the contact frequency the same respondents had with the police. Figure

6.7 shows this cross tabbing done for Afghan National Development Poll 1.0.

	How often have you seen the ANP			
Do you trust the Afghan National Police	Weekly	Monthly (or greater)	Never	Don't Know
Yes	1544	742	250	82
No	64	24	23	4
Don't Know	53	46	578	169

Figure 6.7 Example of Cross Tabbing from ANDP 1.0

In this example, there is a high relationship between those respondents that had frequent contact with the ANP and their trust of ANP. The analyst may consider conducting deeper analysis on the "never" seen the ANP responses to attempt to determine causality.

d. Other Surveys or Studies. The analyst may want to conduct comparative analysis of the findings from their survey with the findings of other surveys or studies conducted by other agencies. The comparative analysis provides another data point and greater fidelity to the assessment process. By comparing the results of your survey with others, you can validate particular findings or determine areas of emphasis that need to be further analyzed due to differing results. The differing results may also prompt the need to include specific questions in a follow-up survey to provide greater insight to the contradicting results.

4. Summary of Importance of Survey

Surveys play an instrumental role in the assessment process. They provide an additional data point to help measure the effectiveness of action plans but more importantly they are essential in assessing the subjective metrics that are inherently found in the metric hierarchy associated with

Campaign Plans. If your command does not fund surveys, the open source surveys and projects conducted by other agencies are still a good source of information to assist in the assessment of the Campaign Plan and should not be overlooked.

CHAPTERVII: EFFECTS BASED ASSESSMENTS

1. Definition and Purpose of Effects Based Assessments

a. Definition. The Joint Warfighting Center defines assessment in the Commander's Handbook for an Effects Based Approach to Joint Operations (24 February 2006). This document supersedes the commonly used reference for Effects Based Operations, Pamphlet 7: Operational Implications of Effects Based Operations (EBO).

Assessment measures the effectiveness of employing friendly capabilities during joint operations to determine progress toward accomplishing tasks, creating an effect, or achieving an objective. This process begins during planning and continues throughout execution. It involves developing relevant assessment measures, continuously monitoring joint force actions, and adjusting plans and operations accordingly. These concepts will be discussed in detail in the remainder of this section.

b. Purpose. Assessment occurs at all levels and across the range of military operations. The term "assess" can apply to a wide range of command and staff activities. The primary focus within this section is on the assessment for the purpose of determining the progress toward attaining accomplishing tasks, attaining effects, and achieving objectives. The assessment process can assist in the determination of progress of meeting objectives outlined in a Campaign Plan at the theater level as well as the progress of specific action plans or tasks that are conducted in support of the creating desired effects and accomplishing objectives.

Assessment measures are considered as early as mission analysis, and include assessment measures and related guidance in commander and staff estimates. The commander and staff use assessments to help guide operational design as these considerations can affect the sequence of actions along lines of operation (see definition in paragraph 2 below). The assessments are used in the decision making process to adjust operations and resources as required, determine when to execute branches and sequels of the plan, and make critical

decisions to ensure current and future operations remained aligned with the desired end state. The assessment also helps to identify potential mismatches between task accomplishment and the achievement of higher-level effects and objectives. The mismatches could result from resource shortfalls, inadequate progress in meeting required milestones, or misdirection of allocated resources or assigned tasks. The assessment looks at operations to date to identify the "delta" between current and desired effects within the Operational Area. The overall assessment seeks to answer the questions "how effective is the plan" and "are the assigned missions, objectives, and desired effects being achieved.

Tactical assessment typically focuses on target engagement and task accomplishment. Assessment at the operational and strategic levels concentrate more on measuring progress toward creating desired effects. Effects assessment is broader than combat assessment and focuses on the measuring of strategic and operational effects that support strategic and operational objectives. Effects assessment helps determine if the command is "doing the right things" to achieve objectives, not just "doing things right" at the tactical level.

Effects can result from both combat and non-combat actions with both lethal and non-lethal means. The commander and staff can use effects assessment to determine progress toward success in non-combat operations for which most tactical level assessments do not apply.

2. Review of Effects Based Operations

a. <u>Key Definitions.</u>

(1) Line of Operation (LOO) – The major grouping of effects or tasks required to achieve operational/strategic, objectives and/or end states.

(2) Objective (End State) – Clearly defined, attainable goals toward which the entire operation is directed. At the operational and strategic levels, objectives focus more

on the intended purpose of an operation, not just the military actions.

(3) Effect – The physical and/or behavioral state of a system that results from an action, a set of actions, or another effect. A change to a condition, behavior, or degree of freedom. A desired effect represents a condition for achieving an associated strategic or operational objective, while an undesired effect could inhibit progress toward the same objective. A single objective may require the achievement of multiple effects.

(4) Key Effect – Effects that are applicable to more than one Line of Operation or Objective.

(5) Measure of Effectiveness (MOE) – A criterion used to assess changes in system behavior or capability that is tied to measuring the attainment of an end state, achievement of an objective, or creation of an effect. Answers the question "Are we doing the right things?" MOEs are usually quantitative measures that can show a trend, as well as progress relative to a numerical threshold. MOEs do not measure task accomplishment or performance of friendly forces.

(6) Measure of Performance (MOP) – A criterion used to assess friendly actions that are tied to measuring task accomplishment. Answers the question "Are we doing things right?" MOPs are generally quantitative, but also can apply qualitative attributes to task accomplishment.

(7) Indicators – One or more metrics that provides system understanding by comparing metrics with standard(s) to assess an action, task, effect, or end state.

(8) Commander's Critical Information Requirements (CCIR) – Critical information requirements that are structured to support the measuring of effects and key decision points. CCIR need to be incorporated into the development of assessment metrics and the assessment process. CCIR

comprise information requirements identified by the commander as being critical in facilitating timely information management and the decision making process that affect successful mission accomplishment.

c. Assessment Metric Relationships. As with the development of plans, the assessment metrics need to be "nested" with the metrics of the higher command. The nesting of metrics allows each level of command to assess whether both the desired effects are being achieved and the objectives are being accomplished. A disconnect in metrics between each level of command causes the assessment process to breakdown. Higher headquarters need to include their objectives and effects within the various plans submitted to lower echelons for execution. This allows the lower echelon's to develop assessment metrics to support the assessment of their own plan as well as the plan of the higher command. A "nested" metric hierarchy should allow assessments to occur from the tactical to strategic levels.

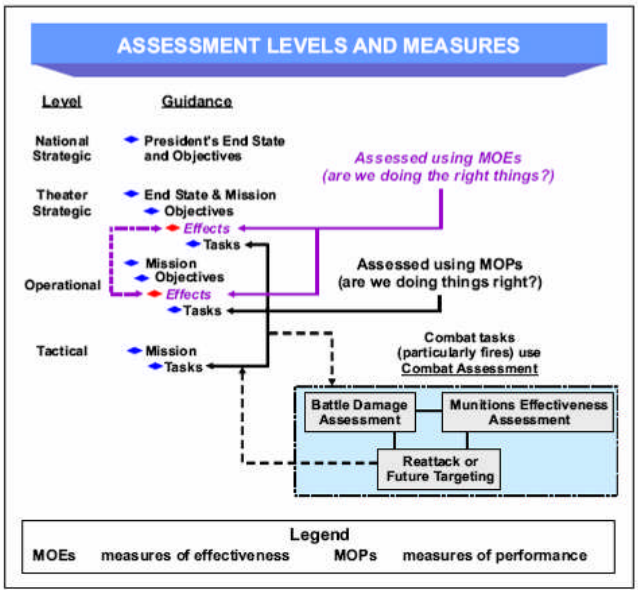

Figure 7.1 Assessment Levels and Measures

Figure 7.1 shows the assessment levels and measures from the national strategic to tactical level. Commanders and staffs understand the necessary requirements to ensure their missions support the accomplishment of the higher headquarters' mission and need to also ensure their assessment measures support the measuring of the higher headquarters' assessment.

3. Developing and Analyzing Metrics

a. Integrated Process. There are two staff organizations unique to the effects-based processes: Effects Working Group (EWG) and the Effects Assessment Cell (EAC). During plan development, the EWG is responsible for the development of strategic and operational effects. Planners and subject matter experts need to be incorporated in the process of developing the metrics and identifying explicit actions required to achieve the desired effects. This group provides the primary venue for developing initial recommendations and effects guidance that directly informs the command and includes the following responsibilities:

(1) Develops Priority Effects List (PEL) and recommends changes to it.

(2) Work with other staffs to determine relationships between of key nodes to desired effects.

(3) Develops MOE indicators and recommends MOE additions or changes.

(4) Conducts analysis to determine why tactical action either contributed, or failed to contribute to the attainment of the desired effect.

(5) Recommends alternate options to planners or future operations staff to address deficiencies in effects attainment.

The EWG needs to ensure that developed effects are measurable and applicable to the stated objective(s) from the

plan. These effects must be done in conjunction with the development of the plan to ensure the desired effect is measurable. If the desired effect is not measurable, planners may need to adjust the plan in order to ensure there is some manner in which to measure success or failure. The EWG group also needs to identify a collection plan. The collection plan should be developed at the same time as the Reconnaissance and Surveillance (R&S) plan. This collection plan identifies the organizations responsible to collect data for specific indicators that feed the assessment of MOEs and effects.

The Effects Assessment Cell (EAC) is the primary venue for assessing the metrics developed in the EWG. The EAC assesses reports and analysis from all available sources to determine if, based upon the status of MOE and associated indicators, the actions are causing the desired system behaviors. The EAC receives inputs from various organizations tasked to report on indicators based on the collection plan. The input is normally objective and quantifiable measures predetermined as part of the planning process. The EAC provides the assessment to the EWG in order to support the planning and decision making process.

b. MOE, MOP, and Indicator Development. The development of MOEs, MOPs, and indicators are the most time consuming and difficult aspect of the assessment process. There is often confusion between these three metrics with MOPs or indicators often being used as MOEs. MOEs are usually worded as "Increasing or Decreasing" of a particular area of interest. For example, the "Increase or decrease in populace support for the judicial system" might be used as an MOE with the following possible indicators:

(1) Number of people using the court system

(2) Number of people entering school for a judicial related degree

(3) Number of judges, clerks, and lawyers

MOEs may also be written in a question format. The wording of the MOE is not important as long as it helps to measure the desired effect. The important concept to remember in developing these three metrics is that MOPs and indicators are used to assess the MOEs. MOPs and indicators measure the accomplishment of the task while MOEs focus on the change in behavior tied to the attainment of an end state or creation of an effect.

Data availability – lower command may already be collecting data for assessing same or similar metric

(4) Use lower command assessment and metrics to feed your assessment process

(5) Utilize MOEs and Indicators of Lower Command

c. Data Collection. As stated earlier, the collection plan needs to be developed in conjunction with the development of the assessment metrics. By incorporating the metrics of the next lower command, this allows for an efficient manner in which to collect needed data or assessments. The lower command may already have a collection plan that can feed your assessment process. In developing the collection plan, the EWG needs to first identify the data already being collected by lower commands and other agencies. This will prevent duplicative efforts on collecting the same data and decrease the burden on responsible organizations. Data not already being collected will have to be tasked to specific organizations. Tasking places ownership and responsibility on the specific organization to provide the data at the stipulated time frames. All elements of database management apply to the collection of data, see chapter III, Data Management Methods for specific details.

4. Decision Cycle

a. EBA Supports Decision Cycle. The EAC provides assessments to the command as required – daily, weekly, or

monthly. Usually the assessment is conducted on a monthly basis to support the decision cycle, however, it is a continuous and iterative process. The continuous aspect of the process allows an assessment to be completed at any given time to meet the needs of the command or staff.

b. Iterative Process. EBA is an iterative process. Assessments are conducted to determine the success or failure of creating desired effects or achieving objectives. Based upon the assessment, new plans may need to be developed or changes made to current plans. As a result, the development or change of assessment metrics needs to occur which starts the planning and execution cycle over again.

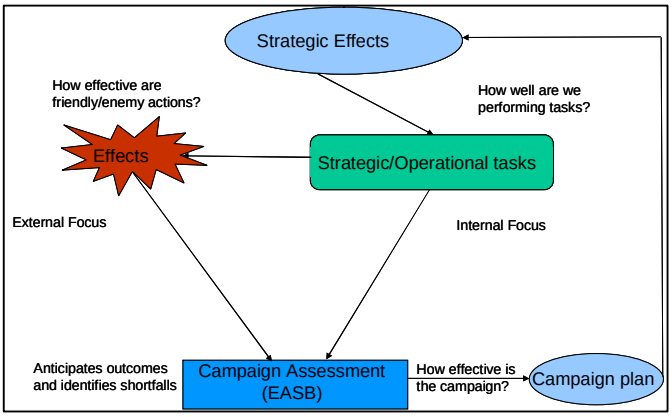

Figure 7.2 Iterative Process Example

Figure 7.2 highlights the iterative process between the planning and assessment processes. The key component of this process is that the development of objectives and desired effects must occur in conjunction with the development of the plan.

The iterative process should provide answers to the following questions:

(1) Are we doing the right things? (external focus)

(2) Are we doing things right? (internal focus)

(3) How are we doing? (progress towards goals)

Providing answers to these questions will allow the assessment to feed the decision making process in determining courses of action in future plans.

5. Additional Sources of Data and Assessments

a. Interagency. During any assessment process, the analyst needs to utilize other assessments conducted by agencies within the U.S. Embassy. These assessments often provide greater insight into the non-combatant operations being conducted in theater to include reconstruction projects being conducted by USAID, political activities being conducted by Department of State, and counter –drug related activities to mention only a few of the tasks that fall within the scope of the interagencies.

b. Surveys. Whether the command funds a survey or not, the analyst should research open source documents, projects, or surveys that can assist with the assessment process. These documents provide an additional data point in assessing a particular metric. If possible, the analyst should attempt to obtain the data used in a particular survey or project to validate the results. Survey development and analysis was discussed in detail in Chapter 5.

c. NATO. The Global War on Terrorism is being fought by many nations. If the situation allows, the analyst should obtain assessments conducted by other nations to provide greater fidelity to your assessment. This relationship should not begin with obtaining assessments but in the developed of metrics and sharing of common data. In Operation Enduring Freedom, the analysts at Combined Forces Command-Afghanistan worked with the analysts at the International Assistance Security Force (ISAF) on the entire effects assessment process.

d. Host Nation. As appropriate, the analyst should incorporate host nation assessments into the overall assessment of the Campaign Plan.

6. Summary of Effects Base Assessments

Effects based assessments play a crucial role in determining the success or shortfalls of any plan or action. In order to provide the greatest benefit to all levels of command the metrics need to be "nested" from the national to tactical levels of command. Many efforts are on going to make this aspect a reality and improve upon the assessment process. Analysts can expect to be intimately involved with the effects based assessment process from development of metrics to analysis supporting the assessment.

CHAPTER VIII: REACHBACK CAPABILITIES

1. Definition and Purpose of Reachback.

a. Definition. Generating Force, i.e., Institutional Army, analytic organizations provide their capabilities through an integrated combination of embedded analysts, either assigned or attached to Army, Joint and Multi-National headquarters, and Reachback. Embedded analysts conduct analysis within their own capabilities, and Reachback to Generating Force organizations when the complexity and/or scope of a given problem exceed their organic capability.

b. Purpose for Conducting Reachback. Operations Research/Systems Analysis (ORSA) applies logical reasoning and sound processes to solve highly complex problems at the operational and strategic level when no readily apparent solutions exist. ORSA employs methods to perform trade-off analysis, compare courses of action, determine the allocation of critical resources, and perform assessment of operational effectiveness. These methods are an integral part of the Army and Joint leaderships' decision-making processes to organize, man, train, equip, sustain and resource the current and future force. Operational analysis is vital to commanders in that it lessens uncertainty in decision-making through sound reasoning and well constructed analytical models.[1]

Reachback allows Operational Army ORSA personnel serving at Division, Corps, Army Service Component Command (ASCC), and Multi-National Command headquarters to drawn upon both the resources and capabilities of Generating Force organizations/institutions. Note the Generating Force consists of those Army organizations whose primary mission is to generate and sustain the Operational Army's capabilities for employment by Joint Force commanders.[2] The following is a non-exhaustive list of factors motivating the use of analytic Reachback:

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1 This paragraph is derived from the British Army's Army Doctrine Publication: Land Operations (May 2005), para 0812.

2 DRAFT of FM1-01 (12 SEP 06) Generating Force Support for Operations

(1) Integration of Analytic Effort. Reachback connects Operational Army analytic efforts to Generating Force organizations. This connectivity ensures analytic relevance along with greater capability within operational headquarters. Specifically, Reachback provides visibility of critical analytical requirements to Generating Force organizations. Additionally, this connectivity allows for the capture of institutional knowledge as deployed analysts are rotated to other assignments.

(2) Subject Matter Expertise. Generating Force organizations possess a wide diversity of expertise. Given the low number of deployed ORSA personnel, Reachback provides a necessary mechanism for tapping this diverse expertise. Note this diversity of expertise is often required with the wide range of analytic challenges faced by deployed personnel.

(3) Manpower. Reachback allows deployed ORSA personnel an opportunity to tap resources beyond their organic capabilities. Also, Reachback allows analysts within Generating Force organizations to obtain data along with contextual reference for theater specific analytic problems.

(4) Analytic Review Process. Reachback provides a natural review process for analytic efforts. By the collaborative aspect of Reachback along with the depth of Generating Force organization capabilities, multiple personnel and at least two organizations will review Reachback analytic products. While this review process will require more time, it will ensure a higher quality of derived products.

(5) Analytic Tools. Reachback provides the deployed analyst access to sophisticated tools and expertise. Figure 8.1, shown below, is one example of the use of a sophisticated software application to graphically represent notional casualty events. In this case, ArcGIS developed centroids based upon the weighted center of an incident cluster.

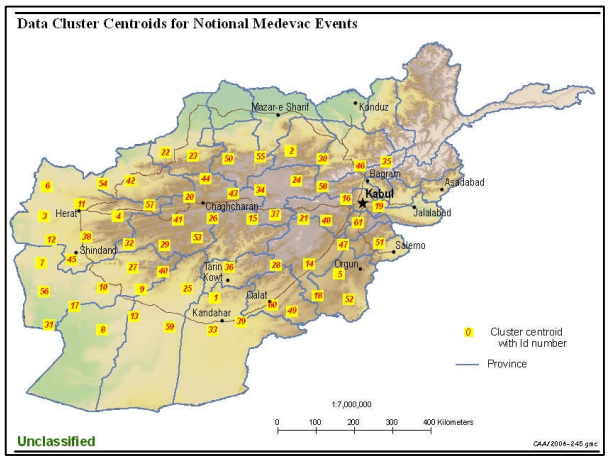

Figure 8.1: Specialized Reachback Tool Example

(The background of Figure 8.1 is topological representation with no effect on the notional dataset.)

(6) Required Surge Capability. The connection between Operational Army commands and Generating Force organizations enabled by Reachback allow for analytic surge capability as required. For example, the Center for Army Analysis (CAA) has provided Deployed Analyst Support Teams (DAST) to ASCCs during major exercises and theater commands from the start of both Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF). An example DAST analytic product is discussed in paragraph **Error! Reference source not found.** on page VII-**Error! Bookmark not defined.**.

c. Reachback Considerations. The following are some considerations for employing Reachback.

(1) Timeliness. Deployed Operational Army headquarters generally operate 7 days per week with 12-14 hour workdays. Analytic requirements from these headquarters often have short term suspenses that may only

span a few days. Generating Force organizations must adapt to these "quick" turn requirements. Also, deployed ORSA personnel must understand the environment within which Generating Force organizations operate. For example, the required review process entails more time in providing analysis. However, this review process ensures a higher quality product.

(2) Confidentiality of Derived Analysis. Generating Force organizations are customer focused. In this case, these organizations must obtain Operational Army command release authority before disseminating derived analytic products. This release authority ensures customer confidentiality in what are often analytic products concerning contentious issues.

(3) Organizational Capabilities. Deployed ORSA personnel should be familiar with the capabilities of Generating Force organizations. This familiarity allows Deployed ORSA personnel to not only incorporate current efforts by these organizations but also to understand where a potential solution source to certain problems may reside.

(4) Contextual Reference. Deployed ORSA personnel must clearly articulate their analytic requirements when requesting Reachback from Generating Force organizations. This ensures the problem is solved within the context of other competing issues that may include timeliness, level of model sophistication, and the essential elements of analysis.

2. Reachback Support Topics

Generating Force organization analytic support to the current fight includes campaign plan assessment, casualty analysis, theater campaign modeling and analysis, force-on-force analysis, stability and support operations analysis, and weapon systems analysis. Note that ORSA topics span Doctrine, Organizations, Training, Materiel, Leadership, Personnel, and Facilities (DOTMLPF). ORSA Reachback support topics include, but are not limited to:

a. Campaign Plan Assessment. Assessment of campaign plans, to include the development of appropriate Measures of Effectiveness (MOE) and Measures of Performance (MOP). See chapter 7 for more detail.

b. Casualty Analysis. Analysis of casualties, to include efficacy of personal equipment, and implications for operating force Tactics, Techniques and Procedures (TTP).

c. Theater Campaign Modeling and Analysis. Theater Campaign modeling focuses on the joint and combined operational/strategic environment. These models incorporate weapon effectiveness data, unit formations, current war plans, etc. in support of campaign analysis. Additionally, Air and Missile defense along with Weapons of Mass Destruction (Chemical, Biological, Radiological and Nuclear) are analyzed at the tactical, operational, and strategic level.

d. Force-on-Force Modeling and Simulation. Generating Force ORSA personnel develop and maintain a class of warfighting force-on-force Models and Simulations (M&S), ranging from individual objects (e.g., soldier, weapon, terrain feature) to theater level models that often aggregate objects (e.g., battalions) at Corps level. The Army Materiel System Analysis Activity (AMSAA) leads Army efforts in modeling platform performance parameters. Training and Doctrine Command (TRADOC) Analysis Center (TRAC) focuses on Corps and below force-on-force combat models while the Center for Army Analysis (CAA) conducts Theater level campaign analysis. Collectively, these models are widely used by the Department of Defense, industry and allied nations.

e. Stability and Support Operations. Generating Force ORSA organizations can contribute to stability operations with a variety of analytic products. Some example analytic products include projects such as the development of campaign plan assessment methods, convoy protection analysis, sensor placement recommendations, basing analysis,

medical asset allocation recommendations, new materiel fielding and utilization analysis, Intelligence Preparation of the Battlefield (IPB) assistance, attack pattern analysis, economic forecasting, force structure/size recommendations, etc. Such ORSA capabilities assist in promoting a secure environment aiding diplomatic and economic programs designed to eliminate root causes of instability. These contributions complement and reinforce overall Stability and Support Operations.

f. Weapon Systems Analysis. Weapons systems analysis enables an understanding of the system, its functions, performance and effectiveness measures, and operational criteria. The ORSA community can provide a comprehensive assessment of the impact of a given friendly or enemy weapons system on the operational environment. The Army Test and Evaluation (ATEC) Command is one Generating Force organization with keen insights in this arena.

g. Programmatic Analysis. The cost of campaigns and major operations strongly affects domestic support, and thus help determine success or failure in a given mission. ORSA personnel aid in decision making with analysis of logistics, force structure, and mobilization/deployment simulation modeling. These projects include force closure estimates, resource for mobilization/deployment data, lift asset requirements, pre-positioning recommendations, and high-level quick response Courses of Action (COA) Analysis. ORSA personnel also conduct estimations of support force (CS/CSS) requirements, casualty analysis, develop Wartime Class V and Class VII requirements, and compare theater logistics requirements verses capabilities.

3. Reachback Process.

a. General. Currently, each ORSA Generating Force organization manages their respective Reachback mechanisms independently. The Center for Army Analysis (CAA) conducts an informal biweekly interagency meeting in an effort to coordinate Reachback efforts. While there is an

effort to consolidate and formalize Reachback contributions from Generating Force organizations, this chapter will only highlight the general Reachback process.

b. Communication Methods. Deployed ORSA personnel and Generating Force organizations communicate by DSN/Commercial telephone, Non-Classified Internet Protocol Router Network (NIPRNET), Secret Internet Protocol Router Network (SIPRNET), Video Telephone Conference (VTC), and Information Work Space (IWS) to name a few means. Periodic communications ensure established relationships between personnel and their respective organizations. Unclassified contact information for ORSA Generating Force organizations follows:

(1) Army Logistics Management College (ALMC) Systems Engineering Department (SED) - http://www.almc.army.mil/sed/ COM (804)765-4633 / 4630 / 4226. DSN 539.

(2) Army Materiel Systems Analysis Activity (AMSAA) - http://www.amsaa.army.mil/contact_us.htm/ COM 410-278-6614. DSN 298.

(3) Army Test and Evaluation Command (ATEC) - http://www.atec.army.mil/contactus.htm/.

(4) Center for Army Analysis (CAA) - http://www.caa.army.mil/contact/contact.htm/ COM (703)806-5527/5680. DSN 656.

(5) National Ground Intelligence Center (NGIC) - http://avenue.org/ngic/contactus.shtml/.

(6) Training and Doctrine (TRADOC) Analysis Center (TRAC) - http://www.trac.army.mil/ /COM (913) 684-5132. DSN 552.

c. Knowledge Management.

(1) Intent. The FA49 Proponent Office along with participating Generating Force organization assistance will maintain a collaborative site on Army Knowledge Online – Secret (AKO-S) to facilitate deployed ORSA personnel operations. Inherent to AKO sites are the capability for webmail, groups, chat communication, file storage, and a search engine. This collaborative site will be available to anyone possessing an AKO-S account.

(2) Vision. The FA49 collaborative website will identify, create, represent, and distribute knowledge for reuse, thereby enabling awareness and learning across the ORSA community with specific emphasis on current operations support. Key objectives of this site are shared intelligence, improved performance, competitive advantage over adversaries, and higher levels of innovation.

(3) Structure. See Figure 8.2, shown below, for the general structure of the FA49 AKO-S collaborative site. Please contact the FA49 proponent office or CAA for the exact location of the SIPRNET site. Note the file structure is based on Generating Force organizations then by supported entity. For example, CAA analytic products are stored by Multi-National Corps – Iraq (MNC-I) and so on. Note that one may send direct links to files or directories within an AKO-S Knowledge Management site to facilitate file reference in addition to using the embedded search engine.

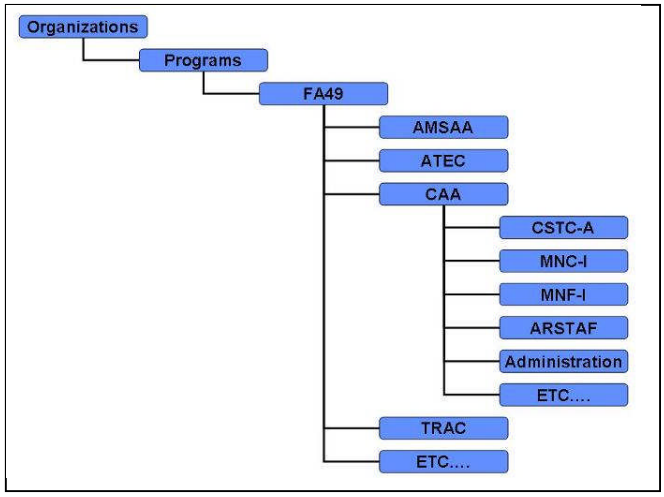

Figure 8.2: AKO-S FA49 Knowledge Management Site Structure

d. Formulating Reachback Problems. In general, Generating Force organizations should adapt to the requirements of deployed ORSA personnel. Especially in terms of the timeliness of derived products. To aid Generating Force organization endeavors, Reachback requests should be formulated with the following information in as much detail as possible:

(1) Problem Statement. Provide a clear definition of the problem along with essential elements of analysis. In particular, what question is to be answered? Additionally, provide a description of assumptions related to how the problem may be modeled. If possible, describe the preferred method of problem solution.

(2) Problem Background. Explain factors/issues bearing on the problem. This will guide literature review and provide insight to Reachback analysts. Describe the ultimate customer and how this relates to other theater efforts. Also, specify the issues surrounding the analysis.

(3) Data. Provide data or recommendations on how to generate/obtain the data necessary for the analysis.

(4) Timelines. Specify desired completion dates and the impact of non-timely analysis. Details on intermediate milestones will aid in project management and ensuring customer needs are met.

(5) Communication. Establish recurrent communication with the supporting agency via the collaborative site on AKO-S and other methods such as the SIPRNET.

(6) Releasability. Specify how and when derived analytic products may be released. Customer confidentiality must be maintained; however, release of analytic products furthers understanding within the FA49 community of current issues/trends.

4. Coordinating Reachback Efforts.

a. Intra/Inter Theater and Interagency Coordination.

(1) Documenting Analyses. Proper documentation of on-going and completed analysis provides an initial starting point for new analysis along with reducing duplication of effort. One simple tool for documenting on-going analysis is maintaining a "quad-chart", shown in Figure 8.3 below, which highlights current project status. Self explanatory, these charts provide a quick means to inform other Generating Force organizations and deployed ORSA personnel of current efforts. These "quad-charts" can be used as a first step in literature review for new problems faced by ORSA personnel. Ultimately, all projects should be documented, by either the Deployed ORSA and/or the Generating Force organization, and submitted to the Defense Technical Information Center (DTIC).

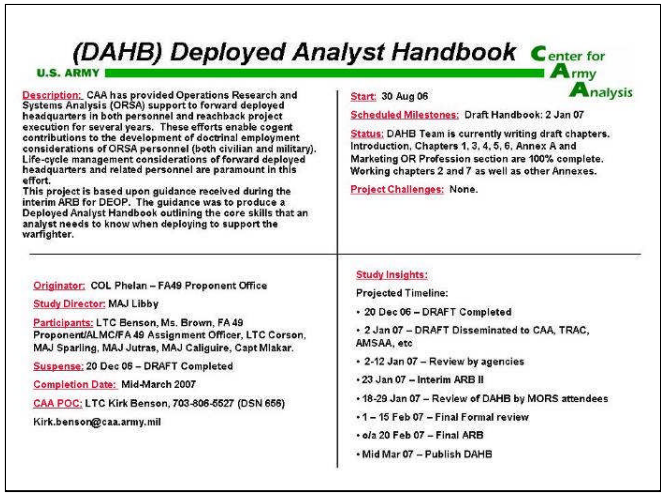

Figure 8.3: Sample Project Quad-Chart

(2) Sharing Data. Data are generally problematic for ORSA personnel. See chapter 2 for details. Regardless, the collaborative site on AKO-S provides a mechanism for sharing data sources. Additionally, the expertise within Generating Force organizations can alleviate many of the issues with data storage and analysis. Data management and analysis will continue to be a source of Reachback contributions.

(3) Recurrent Coordination Meetings. Recurrent meetings provide a venue for coordination and collaboration between Generating Force organizations and deployed ORSA personnel. Continued support of these informal and formal coordination meetings enables effective collaboration.

b. Knowledge Management. The FA49 collaborative site provides a mechanism to manage creation and/or the identification, accumulation, and application of knowledge for the FA49 community. This effort brings together inherent intellectual capital.

3. Generating Force Organizations Available for Reachback.

c. Center for Army Analysis (CAA) Mission. (http://www.caa.army.mil/ (703) 806-5527/5680)

The mission of CAA is to conduct analyses of Army forces and systems in the context of joint and combined warfighting. CAA analyzes strategic concepts and military options along with estimating requirements to support Army inputs to the Planning, Programming, Budgeting, and Execution System (PPBES). CAA evaluates the Army's ability to mobilize and deploy forces, Army force capabilities, force alternatives, along with developing theater force level scenarios and conducting resource analysis.

d. Training and Doctrine Command (TRADOC) Analysis Center (TRAC) Mission. (http://www.trac.army.mil/)

TRAC leads TRADOC's major studies of new warfighting Operations and Organization (O&O) concepts and requirements. TRAC also leads the Army's analysis of Advanced Warfighting Experiments (AWEs), and the Army's Analysis of Alternatives (AoA). The analysis topics span doctrine, training, operations, leader development, organization, materiel, and soldier support. TRAC develops and maintains a class of warfighting Modeling & Simulations (M&S) referred to as force-on-force, ranging from individual objects (e.g., soldier, weapon, terrain feature) to aggregated objects (e.g., battalions) at Corps level. TRAC also develops scenarios of potential military operations set in the future for use in modeling and analysis.

e. Army Materiel System Analysis Agency (AMSAA) Mission. (http://www.amsaa.army.mil/)

Conduct responsive and effective materiel and logistics systems analyses to support decision making for equipping and sustaining the U.S. Army. AMSAA is committed to giving the Soldier decisive capability to win across the

spectrum of future military operations, providing analytical expertise to help guide Army in selecting, acquiring, fielding & sustaining new technologies, and developing the analytical workforce of the future.

f. Army Test and Evaluation Command (ATEC) Mission. (http://www.atec.army.mil/)

ATEC plans, conducts, and integrates developmental testing, independent operational testing, independent evaluations, assessments, and experiments to provide essential information to Soldiers and into the hands of acquisition decision makers supporting the American Warfighter.

e. Non-ORSA Generating Force Organizations. The following Generating Force organizations provide relevant information to many ORSA efforts.

(1) National Ground Intelligence Center (NGIC). http://avenue.org/ngic/. NGIC's mission is to produce all-source integrated intelligence on foreign ground forces and support combat technologies to ensure that U.S. forces and other decision makers will always have a decisive edge on any battlefield.

(2) Joint Improvised Explosive Device Defeat Organization (JIEDDO). The JIEDDO shall focus (lead, advocate, coordinate) all Department of Defense actions in support of the Combatant Commanders' and their respective Joint Task Forces' efforts to defeat Improvised Explosive Devices as weapons of strategic influence.[3]

6. Summary of Reachback

Reachback enhances the productivity and contribution level of deployed ORSA personnel by providing resources and greater capability. Essentially, Reachback augments the

[3] DoDD 2000.19E, February 14, 2006

organic capability of deployed ORSA personnel. Additionally, formalization of the Reachback process ensures the capture of "best practices" along with increased coordination between Generating Force organizations.

ANNEX A: LESSONS LEARNED

1. Purpose

Analysts have deployed to support all levels of commands over the past decade. This section captures the lessons learned from these analysts that will assist and better prepare analysts for future deployments. The lessons learned were obtained from various sources to include analyst input to the Deployed Analyst Survey, final Analysis Review Board presentations given by CAA analysts, discussions at Army Operational Research Symposium, and in email communication with various analysts. The majority of the lessons learned came from deployments in OIF and OEF but are relevant to any theater of operation.

2. Lessons Learned

The following are lessons learned provided by deployed analysts. The lessons learned are presented in issue/recommendation format.

a. Data.

(1) Issue. The lack of or difficulty in obtaining data remains a major factor in being able to conduct in-depth analysis. Analysts cited the following as reasons for these difficulties:

(a) Data maintained by multiple sources – consolidated source does not exist and limited ability to efficiently cross reference data entries

(b) Minimal data collected on incidents – many fields limited to who, what, when, and where.

(c) Text fields contain important information that makes post processing and analysis time intensive.

(d) Collection efforts to obtain data to measure specific metric not planned or executed resulting in not being able to conduct assessment of a particular metric.

(e) Sharing of data – many sources would not share data or data over classified to restrict release to those that needed it for analysis.

(f) Difficult to obtain reconstruction and infrastructure related data from NGOs.

(g) Classification issues limited ability to share data with other coalition analysts.

(2) Recommendation. On going efforts are being conducted to standardize database management. This effort takes into consideration all of the mentioned difficulties associated with obtaining the required data to conduct analysis. The efforts are not complete and analysts can expect to experience some of these same difficulties in the execution of their analysis. Furthermore, analysts should take an active role in correcting any issues with database management and provide input to the on-going effort.

Analysts must also understand and communicate the sources of data and the limitations on the analysis based on the sources and possible lack of completeness. Chapter V, section 3 presents the importance on caveating limitations associated with the data.

b. Pre-deployment Training.

(1) Issue. Many analysts are deploying with minimal knowledge of expectations of support required to the warfighter. Furthermore, analysts are deploying without the required technology to conduct the requested analysis.

(2) Recommendations.

(a) Conduct theater specific pre-deployment training for analysts. This should include software training and briefings on analysis conducted in theater as a minimum.

(b) Data base management – analysts need to be trained on data mining techniques to include use of pivot tables and filtering functions of Excel.

(c) Analysts need to deploy in pairs in order to blend different skill sets to provide greater breadth of analysis to the warfighter.

(d) Deploying analysts should have at least one year of experience in an analytical agency (HQDA, CAA, TRAC, ATEC, etc) prior to deploying – do not deploy a junior analyst right out of school.

(e) Deploying analysts should contact current analyst in theater to gain perspective on command climate and types of analysis being conducted. This is a two-way street as the deployed analyst should open communication with his/her replacement once identified.

(f) Deploy analysts with standardized laptop and with the appropriate software packages in order to conduct the full spectrum of analysis they can expect to execute.

c. Communicating OR Skills.

(1) Issue. Based upon the Deployed Analyst Survey, many analysts believe that the command does not understand the role of an ORSA.

(2) Recommendations.

(a) Analysts need to take the initiative to inform the commander and staff what ORSAs bring to the fight – highlight capabilities in simple terms (see Chapter I: Communicating OR Capabilities) and be confident in your abilities.

(b) Do not be intimated by other staff members – ORSAs bring a problem-solving skill set that few others possess.

(c) Take time to get to know the other staff officers and action officers. Find out what problems they are working and determine how you can provide assistance.

(d) Take time to train other staff officers on various software tools that would make their job more efficient. Many deployed analysts have developed great working relationships with other staff officers by simply showing them the functionality of the pivot table in Excel.

(e) Analysts will most likely not always conducted analysis and will be given non-analytical tasks to accomplish. Remember this is just as important as you are helping the command accomplish its mission. This is also opportunity to build rapport for future analytical work.

(f) Educate senior leaders on what ORSAs can do for them. On-going effort to produce Commander's Handbook on ORSA capabilities.

d. Reachback Support.

(1) Issue. Many analysts are not aware of the reachback capabilities of the various agencies in CONUS.

(2) Recommendation. Reachback process needs to be stipulated to analyst prior to deployment. When mission allows analysts should conduct a visit with different agencies to learn of their reachback capabilities.

3. Summary

The lessons learned stated above are a broad overview of comments provided by previously deployed analysts. Every analyst has had a unique experience with varying levels of issues. Your experience will also be unique but knowing the

issues and difficulties of those that have gone before you will make you better prepared to accomplish your mission.

ANNEX B: CONTRIBUTIONS TO PLANNING AND ESTIMATES OF SITUATION

1. Purpose

a. General. Military commanders are required to make decisions constantly. Every day, they and their staffs resolve simple, routine and/or complex problems. To help them think through their options when faced with a force employment decision, while applying their knowledge, experience and judgment, military commanders use a decision-making tool called the Commander's Estimate of the Situation (CES).

b. Estimate of Situation. Joint Pub 5-0 defines this as "a logical process of reasoning by which a commander considers all the circumstances affecting the military situation and arrives at a decision as to a course of action to be taken to accomplish the mission." The estimate of the situation is an ongoing process, which begins at the inception of the planning phase and ends at the conclusion of operations. The estimate of the situation consists of six principal steps:

(1) Joint Intelligence Preparation of the Battlespace and Mission Analysis

(2) Development of Friendly Courses of Action

(3) Analysis of Friendly Courses of Action

(4) Comparison of Friendly Courses of Action and the Decision

(5) Development of Plans/Orders

(6) Transition

c. ORSA Impact. This annex will highlight specific areas of the planning and estimate of the situation processes that analysts can have a significant impact. Analysts bring a

different perspective to these processes that can greatly enhance the results.

2. Joint Intelligence Preparation of the Battlespace and Mission Analysis

a. Joint Intelligence Preparation of the Battlespace (JIPB). JIPB is the analytical process used by joint intelligence organizations to produce intelligence assessments, estimates, and other intelligence products in support of the joint force commander's decision-making process. ORSAs can contribute to this process by assisting with the analysis to identify the critical vulnerabilities, capabilities, limitations, and intentions of the enemy. Analysts can evaluate and analyze existing databases to identify trends that could support the JIPB process. The databases most likely will not contain all the required information to conduct the analysis. As a result, the analysts can first determine what data is available to support the analysis and then assist in the development of priority intelligence requirements (PIR), requests for information (RFI), collection requirements (CR), commander's critical information requirements (CCIR), the collection plan, and the reconnaissance and surveillance plan to obtain needed data that would provide greater fidelity to the analysis. The data obtained during the collection process will assist the analysts and intelligence organization in assessing the enemy's capabilities and could also shed light on possible enemy courses of action (ECOA).

b. Mission Analysis. The mission analysis contains eight primary steps. Based upon the analyst's operational background, they can play a substantial role in this process. However, even with a limited operational background, the analyst can impact the following two steps by conducting analysis to support the mission development process:

(1) Identify available forces, assets, and noted shortfalls

(2) Conduct initial risk assessment

In recent conflicts, analysts have conducted analysis to assist in the determination of force allocation. Based upon the intelligence estimate and the objective of the operation(s) being planned, the analyst can provide comparative analysis on different force selections. This analysis incorporates both enemy and friendly historical data to determine which forces could participate in the future operation with the least degradation to current environment in their sectors. The comparison of different force allocations would also impact the initial risk assessment. The comparative analysis would highlight the risks associated with the different constructs of the task force being constructed to conduct the future operation.

3. Development and Analysis of Friendly Courses of Action

a. Development. The analytical opportunities are limited during this phase. The analyst can provide input based upon their different perspective to this process. The analysis conducted in JIPB and during the mission analysis phase will impact the development process of the friendly COA.

b. Analysis. Analysts can apply modeling techniques and contribute to the war gaming efforts during this phase. Analysts can contribute in the development, set-up, and conduct of the war-game. Once the war-game is completed, analysts can conduct post-analysis of the results to provide greater insight to the proposed course of action. The analyst can also contribute in the analysis of relative combat power during the war game. This process requires an assessment of both tangible and intangible factors as well as consideration of an inordinate number of those factors either directly or indirectly affecting the potential outcome of the battle. By analyzing relative-force ratios and determining and comparing each force's most significant strengths and weaknesses as a function of combat power, planners can gain some insight into friendly capabilities pertaining to the operation, type of operations that may be possible from both friendly and enemy perspectives, and the vulnerabilities of the enemy. Analysts

should deploy with software and hardware configurations that facilitate wargaming.

However, if the operation is on a large enough scale, the analyst could use reachback capability to conduct a more detailed computer modeling of the operation. Obviously, the reachback request would depend upon the time available to use such capabilities. Center for Army Analysis uses the Joint Integrated Computer Model (JICM) to conduct analysis of large scale operations. This could be utilized to help in the COA analysis phase as time permits. These processes help to identify the COAs' strengths and weaknesses which allow the staff to make adjustments as necessary.

4. Comparison of Friendly Courses of Action and the Decision

a. Comparison. During the comparison step, the commander and staff develop and evaluate a list of important governing factors, consider each COA's advantages and disadvantages, identify actions to overcome disadvantages, make final tests for feasibility and acceptability, and weigh the relative merits of each. This step ends with the commander selecting a specific COA for further CONOP development. Analysts impact this process by assisting in the following:

(1) Identify possible governing factors

(2) Using Effects Based Operations Assessments

(a) What are the desired effects

(b) How do we measure them

(3) Determine how to measure advantages and disadvantages

(4) Prioritize governing factors

(5) Determine weighting of governing factors as needed

(6) Determine range of values of assigned scores for each governing factor

b. Decision. The techniques for conducting the comparison vary, but all must assist the commander in reaching a sound decision. A 'decision matrix' is used to facilitate this process. This matrix numerically portrays the subjectively chosen and subjectively weighted governing factors. This process was discussed in paragraph 4.a. Analyst impact this process by ensuring sound principles are used in applying the range of values to the governing factors and appropriate weights are used, if required.

5. Development of Plans/Orders

Analysts impact this process by ensuring the desired objectives and effects of the plan are measurable. The analysts need to work with the planners during this phase to assist in the development of metrics (Effects, MOEs, MOPs, and indicators). An annex detailing the metrics should be included as part of the published order. The collection plan identifying the responsible unit or agency should also be included in the assessment annex. This collection plan needs to be developed in conjunction with the metrics and tied to the R&S plan. Ensure you understand CCIR, the decision support template, and other planning tools as they relate to information gathering, metric development, and the commander's decision making process. These may require additional "requests for information" to be submitted along with the operations order. Once the data is collected, analysts will play an instrumental role in conducting the analysis and assessment to determine whether the desired effects were achieved.

6. Transition

Transition is an orderly turnover of a plan or order as it is passed to those tasked with the execution of the operation. It provides information, direction and guidance relative to the plan or order that will help to facilitate situational awareness. Successful transition ensures that those charged with

executing the order have a full understanding of the plan. Analysts impact this process by ensuring analysts at other levels of command understand the assessment metrics and collection plan. Coordination with all analysts with in the commands of the order needs to occur. During the assessment phase, analysts need to coordinate analysis efforts to negate duplicative efforts but to also compare findings. A coordinated effort will provide commanders with greater details and fidelity to make sound decisions.

7. Summary

Analysts have and continue to impact the planning process and estimate of the situation to allow commanders to make informed decisions in the execution of the Global War on Terrorism. Analysts at all levels of command need to integrate themselves into the estimate of the situation process. Analysts bring a different skill set and perspective to this process which will provide more in-depth information for the commanders to base their decisions. Furthermore, being involved from the beginning of the process will also allow analysts to conduct more detailed analysis during the assessment phase.

ANNEX C: PROBLEM SOLVING FORMAT

1. Introduction

In an environment of political advocacy, organizational hierarchies, and budget constraints, Army analysts face decision making processes that often operate by rules different from a directed, scientific system. Army analysts, armed with technical methods for problem solving, often encounter analytical land mines when attempting to apply the scientific method in the Army's decision making environment.

2. Purpose

This annex will offer some non-technical guidelines and to provide a structural framework within which Army analysts can apply their scientific craft.

3. Preliminary Assessments

Prior to and during work on the project, take stock in the following issues: Understand the problem.

a. Take a broad view, free of parochialism standard procedures and traditional approaches.

b. Be creative; use innovative thinking in exploring alternate approaches to the problem.

c. Be thorough; describe the limits of the proposed analysis, so that both the analyst and the study sponsor have a clear idea of what will not be done, as well as what will be done.

d. Keep the sponsor informed concerning all developments, changes, and constraints to the analytical effort.

e. Seek practical results and recommendations that are capable of being implemented.

f. Be responsive and on time. An answer that is 100% right, but is late, is of no value to anyone.

4. The Study Process

Figure C.1 depicts the study process as outlined in 'Guidelines for Army Analysts' developed by ALMC, February 1989.

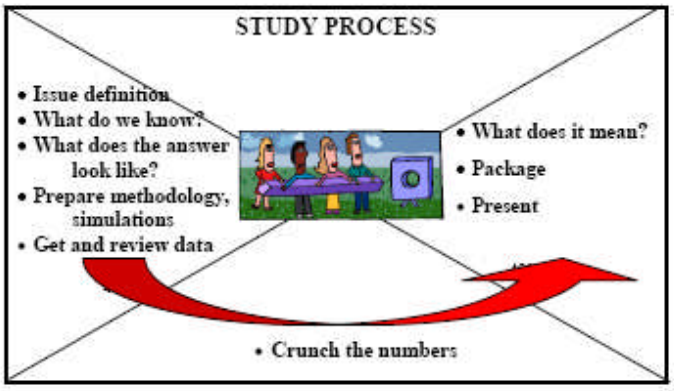

Figure C.1 Study Process

The following paragraphs will provide greater detail of each step in the study process.

a. Identify the issue: Problem formulation. Problems must be defined from the perspective of the *problem owners*, not from the perspective of the problem solvers. In order to zero in on the real problem, the analyst must make every attempt to get face to face, or voice to voice, with the key problem owner. It is critical to establish exactly who cares about the various issues to determine which are key and which are "nice to know."

b. Determine what is known: Observe the current system. The diversification of study efforts among overlapping organizational missions almost guarantees some duplication of effort. Many problems that arise today have

occurred before; and many have been solved before. To additionally insure that decisions are not made with needlessly insufficient information, the analyst must conduct a thorough literature search during the early stages of the problem solving process.

c. Formulate a mathematical model of the problem: What is the hypothesis? Early in the study process, the analyst must reason through the issues of the problem and attempt to determine what the answer may be, close enough to gain some appreciation for the problem's order of magnitude. This will alert the analysts to the critical and key issues of the problem and will identify the "drivers" behind the decision.

d. Prepare Methodology: Define solution techniques by selecting the technique which best fits the problem, some analysts inversely attempt to apply the problem to a pre-selected technique. The analyst who attempts to force the problem to confirm to a pre-selected methodology is usually considering only a narrow selection of variables and alternatives with which he has the most familiarity. By definition, a model is a simplified representation of the entity it stimulates. Inherent in this definition is the unavoidable fact that every model contains imbedded assumptions and intrinsic limitations.

e. Gather and Review Data: Part of the analyst's job is to discern what information is pertinent and meaningful, and to use this data in the problem solving process. Many study efforts are based on sound analytical design; however the results of these studies become questionable when the techniques are applied to invalid data or unchallenged "official" figures. Analysts must examine all the data upon which the analysis is based, determine how it was derived, and check it for accuracy. It is important to remember that one of the key functions of the data gathering procedure is that of rejecting bad data and inaccurate information.

f. Conduct Analysis: Given that the front-end part of the problem solving process has been completed, it is now

time to turn on the calculator, PC, or mainframe and let the computers carry out the drudgery of any detailed and repetitious mathematical computations. The problem solver must acknowledge that qualitative analysis, a subjective assessment of the more intangible attributes of the problem, also has a place in the evaluation process. Analysts must not overemphasize the use of numbers. Numbers provide insight to answers, and are not answers in themselves.

g. Interpret Results: The analyst must compare these results to those results obtained to those results obtained through the front end analysis. If these results are in agreement with each other, then the analyst's intuitive solutions have been validated by the actual results. If the results of actual study do not agree with the solutions to the front end analysis, then one of the following two situations has occurred: 1) An error was made in number crunching **OR** 2) A non-intuitive answer has been discovered. Problem solvers must produce recommendations that make sense within the operational framework of the sponsoring organization, as opposed to pursuing an aesthetically pleasing approach that cannot be implemented.

h. Translate your findings: Problem solvers must package results of their analytical effort so that decision makers can understand the insights and implement the recommendations and avoid additional confusion to an already complicated decision issue. Non-technical marketing must be accomplished. This non-technical marketing can be successfully accomplished through effective communication of the study results.

i. Present your findings: Communication of analytical findings can take place in two ways: written reports and briefings. While written reports can provide excellent technical documentation of a study, nearly all major decisions in the DoD today are based on the merits of the BRIEFING, not the written report. The briefing has become the arena in which senior DoD officials acquire information, examine alternatives, and make decisions. Refer to Chapter 4 for

additional information on Representing Data/Information and Chapter 1 for additional information on Communicating OR Capabilities.

ANNEX D: STATISTICAL ANALYSIS

1. Purpose

a. General. This annex presents an example of using descriptive statistics and a t-test to analyze aspects of battlespace transition.

b. Background. In Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF), battlespace is turned over to host nation forces. Assessments are conducted prior to the transition to determine if conditions are favorable for this to occur. Follow-on analysis and assessments are conducted to determine the effectiveness of the battlespace transition. The following example uses a real-world situation with notional data to present the use of statistical analysis in conducting the battlespace transition assessment.

2. Problem and Formulation

a. Problem. Leadership has made the assertion that there is a decrease in attacks after battlespace transition. The analysts have been asked to provide analysis to validate or negate this assertion.

b. Formulation. The first step is to conduct data mining and cleaning to obtain the attack data for the specified battlespace (province). This can easily be accomplished by using a Pivot Chart within Excel to access only the data fields needed for the analysis. Once the data has been mined and cleaned, the analyst should calculate the descriptive statistics of time periods before and after the transition of battlespace. The descriptive statistics should also include a histogram. The histogram will allow the analyst to gain insight of the underlying distribution of the data. Table D.1 shows the descriptive statistics for the two time periods, before and after transition of battlespace:

	Before	After
Mean	126.9	101.1
Standard Error	1.9408	1.9915
Median	126.6582	101.1846
Mode	#N/A	#N/A
Standard Deviation	9.8961	10.1549
Sample Variance	97.9333	103.1227
Kurtosis	0.3540	-0.4379
Skewness	-0.0607	0.2294
Range	42.9362	37.8734
Minimum	104.9310	83.8071
Maximum	147.8672	121.6805
Sum	3299	2630
Count	26	26

Table D.1 Descriptive Statistics for Two Time Periods

The mean would indicate that the assertion is false but the analyst needs to conduct an appropriate test to determine whether there is statistical significance between the two observed means for the two time periods. Figures D.1 and D.2 are the histograms for the before and after time periods.

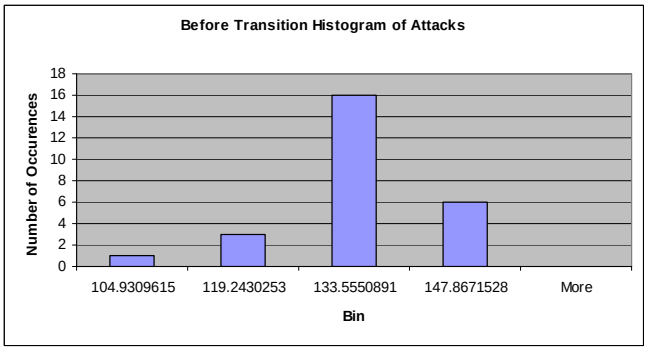

Figure D.1 Histogram for Before Transition Time Period

The histogram in Figure D.1 appears to have an underlying normal distribution. Analysts could use a more rigorous normality test such as the Anderson-Darling test to verify the normality of the distribution. Many sites on the internet give a good explanation of the Anderson Darling Test for normality.

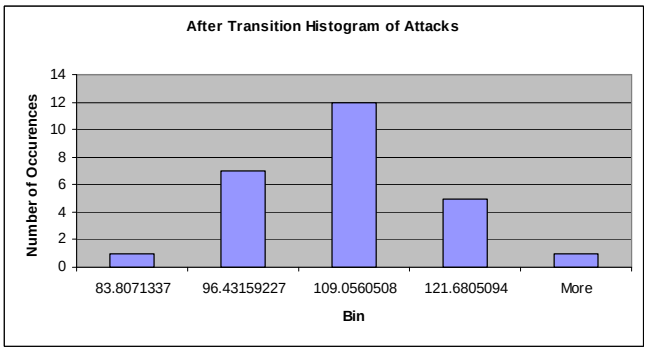

Figure D.2 Histogram for After Transition Time Period

The histogram in Figure D.2 also appears to have a normal distribution. Based off the underlying normal distribution for the datasets, the analyst can appropriately use the t-test to determine the statistical significance of the means.

3. Statistical Test

a. T-test.

(1) General. The t-test considers the null hypothesis that the means of two normally distributed populations are equal. Given two data sets, each characterized by its mean, standard deviation and number of data points, we can use some kind of *t* test to determine whether the means are distinct, provided that the underlying distributions can be assumed to be normal.

(2) Analysis. Excel has built-in functions in the "data analysis" add-in to conduct a t-test. In this case, the analyst would conduct a "two-sample t-test with unequal variances". The variances were calculated in the descriptive statistics. Excel produces an output table for this test. Table D.2 shows the output for the analysis of this example:

	Before	After
Mean	126.9	101.1
Variance	97.9	103.1
Observations	26	26
Hypothesized Mean Difference	0	
df	50	
t Stat	-9.2570	
P(T<=t) one-tail	1.01E-12	
t Critical one-tail	1.6759	
P(T<=t) two-tail	2.02E-12	
t Critical two-tail	2.0086	

Table D.2 Excel Output for t-test

The small "p" value of the one-tailed t-test indicates that there is strong evidence that the mean of the two time periods are different.

b. Conclusion. Based upon the results of the t-test, the analyst can conclude that there is statistical significance in the difference of the means for the two time periods. As a result, the assertion by the leaders is correct for the battlespace transition for this particular province. There is statistical significance showing that attacks do decrease after the battlespace transition.

4. Summary

The example in this Annex provides analysts with a method to conduct a statistical analysis project. Analysts should begin with descriptive statistics, to include some type of graphical representation of the data, to gain insight of the data. This example used notional data of a real-world project conducted in theater to provide analytical rigor to an assertion made about battlespace transition. "Data Analysis and Decision Making with Microsoft Excel" by Albright, Winston, and Zappe is a good reference for conducting statistical analysis.

ANNEX E: RESOURCE ALLOCATION MODEL

1. Purpose

a. General. This annex uses a real world project conducted by Center for Army Analysis (CAA) in support of theater analysts deployed to Operation Enduring Freedom. The analysis incorporates Monte Carlo Simulation and Optimization (Goal Programming) in the methods to obtain the recommended allocation of resources. Although certain aspects of this problem could be conducted by analysts in theater, the project is more conducive to a reachback request to agencies in CONUS.

b. Background.

(1) Purpose. To present results and insights gleaned to date pursuant to analysis of the geographic positioning of air ambulances in Operation Enduring Freedom (OEF).

(2) Problem Statement. "Given a distribution of MEDEVAC missions, where do coalition forces position 'h' helicopters amongst 'p' possible locations to minimize time from injury to arrival at a role (aka echelon / level) 2 or 3 medical treatment facility? Given that positioning, what % of MEDEVAC missions would result in < 2 hours from time of to arrival at Role 2 or 3 facility?"

(3) Facts.

(a) Destination medical treatment facilities (MTFs) are the 21 role II and above (aka level II+, echelon II+) locations (provided by sponsor) z1, z2, z3 , . . . z21

(b) Air ambulances can be field sited at 25 possible locations (provided by sponsor) j1, j2, j3 , . . . j25

(c) Air ambulance types and constraints (provided by sponsor) shown in figure E.1.

Model	Nationality	Quantity	Location Constraints	Additional Comments
k_4	Nation 1	1	Only j_4	
k_5	Nation 2	2	Only j_5	
k_1	Nation 2	c_1	none	
k_2	Nation 3	c_2	none	
k_3	Nation 4	c_3	Only those j's in certain regions	Initial run limit to c_3-3 aircraft (3 dedicated to search and rescue) Subsequent run use all c_3

Figure E.1 Air Ambulance Types and Constraints

(d) No mixing of models at same location

(e) No lone aircraft (minimum of 2) except the k4 at j1

(4) Assumptions.

(a) Geographically variant medevac demand is derived from empirical medevac data and therefore historical trends are assumed representative of future requirements.

(b) Other assumptions are addressed at applicable step in analytical methodology

c. Methodology. Figure E.2 describes the methods used by the CAA analysts in determining the recommended allocation of resources.

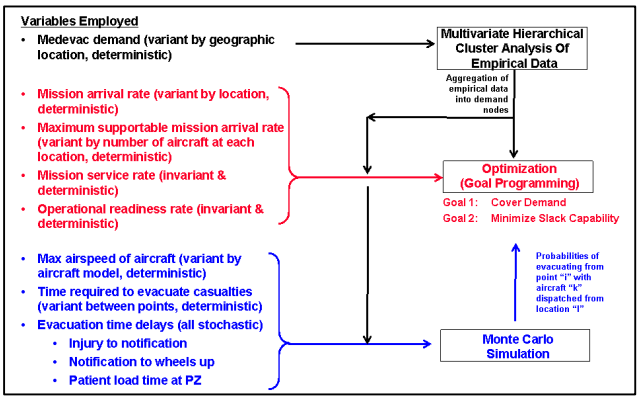

Figure E.2 Methods Used in Analysis

Cluster analysis was conducted on the historical medevac demand data in order to aggregate the data into demand nodes. The demand nodes were then used in both the optimization and Monte Carlo Simulation analysis. Mission arrival rate, maximum supportable mission arrival rate, mission service rate, and operational readiness rate were the other variables used in the optimization (goal programming) analysis. Maximum airspeed of the aircraft, time required to evacuate casualties, and evacuation delays were the other variables used the Monte Carlo Simulation. The Monte Carlo Simulation determined the probabilities of evacuating casualties from point "i" with aircraft "k" dispatched from location "j". These probabilities were then used in the optimization model.

2. Analysis.

a. Cluster Analysis.

(1) Essential Elements of Analysis (EEA). What are the minimum number of clusters necessary to allow maximum data reduction while retaining sufficient definition of geographically variant evacuation demand?

(a) Facts. Data source: medevac mission data provided by theater

(b) Assumptions:

- Number of missions per cluster allowed to freely vary between 1 and the total number of missions in dataset
- Maximum time from cluster centroid to medevac locations comprising cluster NTE 15 minutes
- Weighting of each medevac location by number of casualties
- Use of Manhattan distance (sum of absolute distances) vice Euclidean distance to limit outliers' effects

(2) Measure of Effectiveness: number of clusters, cluster locations (latitude and longitude), average intra-cluster distance from centroid to locations comprising cluster, maximum intra-cluster distance from centroid to locations comprising cluster

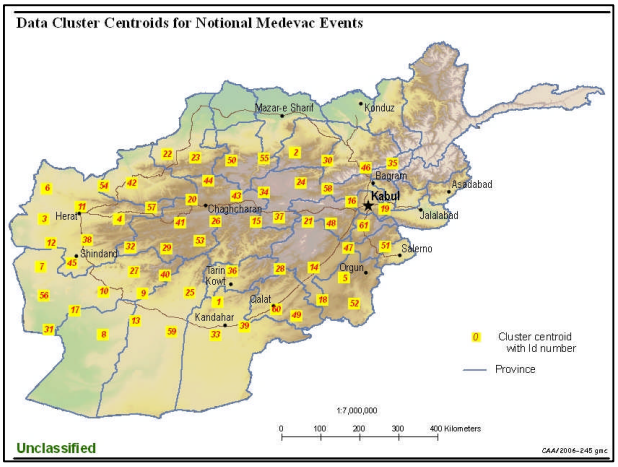

Figure E.3 Notional Results of Cluster Analysis

Figure E.3 shows notional results of the cluster analysis conducted on the historical Medevac data. The demand nodes

are then used in the optimization analysis and Monte Carlo Simulation. The cluster analysis was conducted using ARCGIS which is a tool that many analysts are now receiving training on prior to deployment.

b. Monte Carlo Simulation.

(1) EEA. What is the probability of evacuating within 2 hours from each of the demand clusters from each of the 25 possible air ambulance locations using each type of aircraft possible at that location?

(2) MOE. Probability of evacuating from each cluster centroid using each type of aircraft from each possible

Demand Nodes (Clusters)	Possible Medevac Locations	Aircraft Models	Total Combinations
61	25	3	4575
		Trials	100,000
		Total Trials Employed In Simulation	457,500,000

Table E.1 Trials Employed in Monte Carlo Simulation

(3) Assumptions. Medevac time per trial = (a + b + c + d + e)

(a) Time of injury to notification: assumed triangular distribution (5, 10, 15)

(b) Time of notification to wheels up:

- All less CH47: assumed inverse weibull distribution based on sample data provided by theater (0, 2.78, 3.95e-002)
- CH47: assumed inverse weibull distribution based on sample data provided by theater (0, 2.78, 3.95e-002) x multiplier of 2 (based on theater‘s CH47

estimate = 2 times that of all other aircraft)

(c) Flight time to pickup location (i.e., cluster centroid): assumed deterministic based on aircraft flight speed

- Initially 120mph
- Subsequently to be variant by aircraft

(d) Time for patient load time: assumed triangular distribution (5, 10, 15)

(e) Flight time to closest MTF: assumed deterministic based on aircraft flight speed

- Initially 120mph
- Subsequently to be variant by aircraft

(4) Solution Sets.

- No intra-cluster evac time
- Additive with average intra-cluster evac time: assumed deterministic
- Additive with max intra-cluster evac time: assumed deterministic based on aircraft flight speed

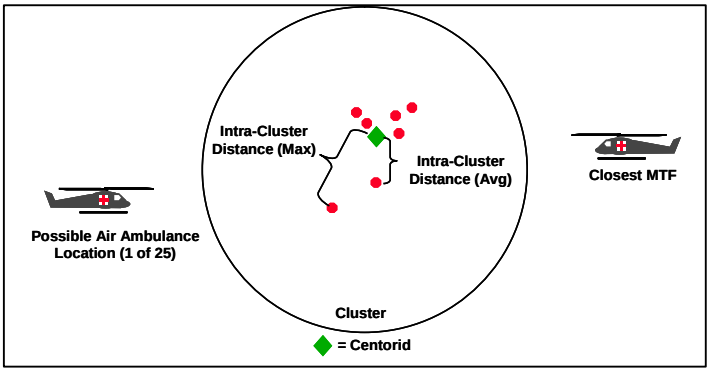

Figure E.4 Illustration of Solution Sets

(5) Results of Monte Carlo Simulation. Table E.2 shows the notional results from the Monte Carlo Simulation.

Cluster	Max Probabilty From Any Location	% of Last Year's Medevac Demand	Cluster	Max Probabilty From Any Location	% of Last Year's Medevac Demand	
C50	0.975	C50's %	C32	0.928	C32's %	
C17	0.974	C17's %	C49	0.927	C49's %	
C14	0.971	C14's %	C6	0.926	C6's %	
C22	0.970	C22's %	C59	0.926	C59's %	
C9	0.970	C9's %	C46	0.923	C46's %	
C41	0.970	C41's %	C3	0.920	C3's %	
C37	0.969	C37's %	C61	0.917	C61's %	
C10	0.969	C10's %	C18	0.916	C18's %	
C23	0.967	C23's %	C11	0.916	C11's %	
C30	0.966	C30's %	C45	0.905	C45's %	
C21	0.966	C21's %	C8	0.899	C8's %	
C1	0.965	C1's %	C43	0.898	C43's %	
C52	0.963	C52's %	C28	0.888	C28's %	
C12	0.963	C12's %	C19	0.885	C19's %	
C60	0.962	C60's %	C27	0.885	C27's %	
C34	0.960	C34's %	C42	0.885	C42's %	
C7	0.960	C7's %	C4	0.884	C4's %	
C48	0.955	C48's %	C58	0.879	C58's %	
C13	0.954	C13's %	C25	0.868	C25's %	
C55	0.952	C55's %	C51	0.857	C51's %	
C40	0.952	C40's %	C54	0.857	C54's %	Aggregate Percent of Last Year's Demand
C56	0.949	C56's %	C20	0.854	C20's %	
C24	0.949	C24's %	C35	0.797	C35's %	
C36	0.948	C36's %	C15	0.775	C15's %	
C29	0.947	C29's %	C53	0.741	C53's %	
C16	0.945	C16's %	C33	0.674	C33's %	ΣC53's through C38's Percentages
C26	0.939	C26's %	C44	0.546	C44's %	
C5	0.936	C5's %	C39	0.469	C39's %	
C47	0.936	C47's %	C57	0.330	C57's %	
C2	0.935	C2's %	C38	0.147	C38's %	
C31	0.931	C31's %				

Table E.2 Notional Results of Monte Carlo Simulation

The probabilities displayed are the maximum probability of evacuating from each cluster using any of the 25 medevac locations and applicable airframes. There are 9 locations that, no matter where aircraft are located, have less than a 75% chance of being serviced within 2 hours. Together these nine clusters constitute approximately 7% of the annual medevac demand. Also of note there are two clusters, C57 and C38, which have a 0% chance of being serviced within 2 hours. These two clusters represent 0.63% of the annual medevac demand. These probabilities were then utilized in the optimization (goal programming) analysis.

c. Optimization (Goal Programming).

(1) Goals.

(a) Maximize the aggregate expected demands covered (i.e., minimize the aggregate underachievement deviation (d-) of expected demands covered)

(b) Minimize the spare capacities of air ambulances at each individual location (i.e., minimize the overachievement deviation (d+) of spare capacities at each individual location) while ensuring goal 1

(2) Variables and Equations. Figure E.5 defines the variables used in the optimization equations.

G_1 : Goal 1

d_1^- : Goal 1 under-achievement deviation

G_2 : Goal 2

d_2^+ : Goal 2 over-achievement deviation

i : Demand nodes: i = 1, 2, 3, . . .n

j : Potential medevac locations; j = 1, 2, 3, . . .m

k : Aircraft types; k = 1, 2, 3, . . .t

s : Number of type k aircraft to be co -located {2,3,4}

c_k : Number of type k aircraft available in theater

a_i : Proportion of demand originating in area I

λ_i : Actual demand rate in node i

r_{ks} : Boundary value in the demand rate from s to s+1 type k aircraft

P_{ijk} : Probability of evacuating from area I within 2 hours with aircra ft k dispatched from location j if > pre -specified probability p = 0; 0

X_{jks} : 1 if s number of k type aircraft are to be considered for positi oning at location j; 0

Y_{ijk} : 1 if > pre -specified probability p and j is the nearest open location and f acilitates evacuation within 2 hours; 0

Figure E.5 Variables Used in Optimization Equations

Figure E.6 displays the equations used in the optimization analysis.

$$\text{Objective Function}: \quad Min \left(G_1 d_1^- + G_2 \sum_{j=1}^{m} \sum_{k=1}^{t} d_{jk}^+ \right)$$

$$G_1 : Max \sum_{i=1}^{n} \sum_{j=1}^{m} \sum_{k=1}^{t} a_i P_{ijk} Y_{ijk} \quad \therefore \sum_{i=1}^{n} \sum_{j=1}^{m} \sum_{k=1}^{t} a_i P_{ijk} Y_{ijk} + d_1^- = 1 \; ; \quad 0 \le d_1^-$$

$$\text{subject to} \quad \sum_{j=1}^{m} \sum_{k=1}^{t} Y_{ijk} \le 1 \qquad \forall i$$

$$G_2 : Min \; r_{ks} x_{jks} - \sum_{i=1}^{n} \lambda_i Y_{ijk} \quad \therefore \sum_{1<s<5} r_{jks} x_{jks} - \sum_{i=1}^{n} \lambda_i Y_{ijk} - d_{jk}^+ = 0; \quad 0 \le d_{jk}^+ ; \quad \forall \; d_{jk}^+$$

$$\text{subject to} \quad \sum_{1<s<5} X_{jks} \le 1 \qquad \forall \; jk$$

$$\text{and} \quad \sum_{1<s<5} \left(s \sum_{j=1}^{m} X_{jks} \right) \le c_k \qquad \forall k$$

Figure E.6 Optimization Equations

Using the equations above, analysts were able to optimize the two goals of providing coverage demand and minimizing slack capability. The following two figures show notational results from this project.

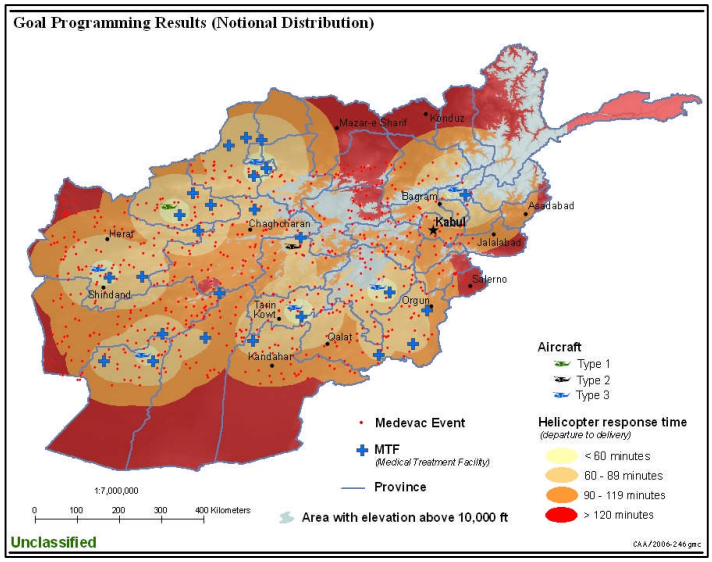

Figure E.7 Geospatial Representation of Notional Results

Figure E.7 shows the results using ARCGIS to spatially show the locations of Medical Treatment Facilities (MTF) and helicopters.

Run	Model	Location	Number
k_3 Helcopters limited to c_3-3	k_4	j_4	1
	k_5	j_5	2
	k_1	j_1	c_1
	k_2	j_2	c_2
	k_3	j_{31}	c_{31}
		j_{32}	c_{32}
		j_{33}	c_{33}
		⋮	⋮
		j_{3n}	c_{3n}

Run	Model	Location	Number
all c_3 k_3 Helcopters	k_4	j_4	1
	k_5	j_5	2
	k_1	j_1	c_1
	k_2	j_2	c_2
	k_3	j_{31}	c_{31}
		j_{32}	c_{32}
		j_{33}	c_{33}
		j_{34}	c_{34}
		⋮	⋮
		j_{3n}	c_{3n}

Table E.3 Notional Medevac Positioning

Table E.3 shows the notional Medevac positioning; same results as seen in figure E.7.

ANNEX F: NETWORK FLOW MODEL

1. Purpose

a. General. This annex presents an example of using a network flow model to determine the best path through an AOR to maximize the search area and to maximize the chance of detection. Although this problem is not focused on OIF or OEF, the application of the problem is relevant to many networks that are present in the Global War on Terrorism. The methods used could easily be adjusted to model and examine enemy communication, weapon, and money networks. Commanders could use these models and the associated analysis to determine the best course of action to disrupt the flow of the enemy's networks.

b. Background. One of the missions of the US Navy is to support the US Coast Guard, CIA and DEA in their attempts to reduce the amount of drug trafficking into the United States. There are two large areas that surface and air assets constantly patrol in support of this mission. The dividing line is the Mexico-Guatemala border dividing the responsibility between two agencies, Joint Interagency Task Force East and Joint Interagency Task Force West. JIATFW is primarily concerned with sea going vessels inbound for Mexico and southern US ports. JIATFE covers all outbound narcotic trafficking from South America on both sides of the Panama Canal, through the Lesser and Greater Antilles and Windward and Leeward passages in the Eastern Caribbean.

Narcotics smugglers use a small, high speed vessel, commonly called a Go-fast, that is capable of speeds of up to 40+ knots when empty and 30+ knots when fully loaded. These small boats usually have 3 to 4 Yamaha outboard engines, have no navigation systems or radars and their only communication is a HF radio to call back to base to report their progress. There only means of navigation is typically a small hand held GPS that has way points entered into the system prior to departure. This makes it more difficult for US assets to intercept these vessels because there are no radar emissions that can be intercepted by US assets. To further

camouflage their transits, the boats are pointed blue and maintain a very low profile making them extremely difficult to see with the naked eye.

c. Assets. US ships and aircraft are utilized in this mission but this project focuses on analyzing the use of aircraft. Air coverage is provided by either a shipboard helicopter or by a number of DEA/CIA aircraft and US Navy P3C Orion aircraft. The aircraft only have a limited amount of time on station, but they are capable of searching much larger areas in a faster amount of time with a lesser threat of counter detection. Air assets are extremely important in the detection of narcotic smuggling vessels, and they need to be utilized to their maximum capabilities.

2. Problem and Formulation

a. Problem. Joint Interagency Task Forces need to determine how to best utilize the air assets within their command. A networking model can be used to determine the best path through an AOR to maximize the search area and to maximize the change of detection.

b. Formulation. The first step is to construct the network. The AOR can be divided into several smaller areas whose sum of areas is equal to that of the AOR. Each sector does not have to be the same size, in fact, they shouldn't be the same size. The AOR is divided into sectors arbitrarily at the discretion of the planner. The size of the sectors ca be dependent on land masses, proximity to fishing lanes, and commercial trafficking lanes. Each sector is assigned a Detection Rating (DR) that assigns a numerical value that ranks each area in possibility of detecting a narcotic trafficking vessel. For this model a random number generator (with some restrictions) was used to determine the values of the square mileage of each sector and their corresponding DR values.

(1) Assumptions

(a) This model assumes that the aircraft is only making one pass through the AOR, from the northern edge to the southern edge. A model can be created that allows for passage to adjacent sectors in every direction, however, a number of decision variables would have to be added. The decision variables will be the paths that the aircraft is allowed to travel to the next adjacent sector. Figure F.1 is a rough drawing of a possible layout for the paths between sectors:

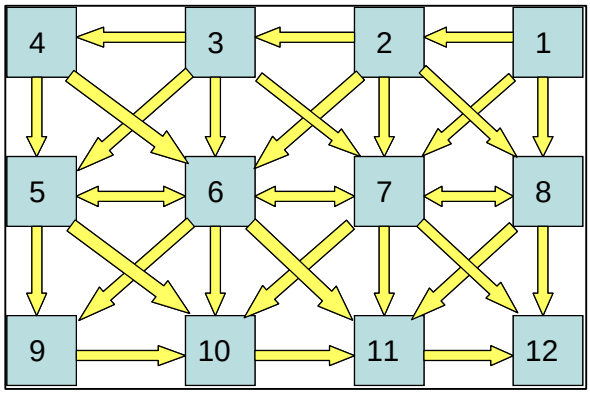

Figure F.1 Network Flow Model

(b) Another assumption that this model makes is that the entry and exit points of the air asset are predetermined and can not be changed. Sector 1 and 12 (see Figure F.1) were chosen as the entry and exit points for this model, respectively. The entry and exit points have no bearing on the AOR layout, but the constraint equations will change significantly if a new entry or exit point is chosen.

(2) Constraints

(a) The constraint equations comprise of an analysis of each sector and what the possible entry and exit routes for each sector are. Sector 1 has no entry route, but

contains two exit routes so the constraint equation for Sector 1 would be as follows:

- -X12 – X18 – X17 = -1

A negative one is assigned because the aircraft must leave the sector.

(b) Sector 12 is evaluated and assigned a value of 1 because the aircraft must leave through Sector 12. The constraint associated with Sector 12 is:

- X112 + X712 = 1

(c) The rest of the sectors are formulated and assigned the values of 0. These constraints ensure the aircraft will not terminate in a sector that is not designated as the exit sector. The following are two examples of the constraints associated with the other sectors:

- 2: X12 – X23 – X26 – X27 – X28 = 0
- 4: X34 – X45 – X46 = 0
- 9: X59 – X69 – X910 = 0

(d) There are three routes that are "two-way" routes and require specific constraints to ensure that the aircraft does not backtrack and search a sector that has already been searched. These routes are between Sector 5 and 6, Sector 6 and 7, and Sector 7 and 8. These constraints simply state that once the aircraft has traveled in one direction, it can not go back on the same return path. The formulation for the "two-way" path between Sectors 5 and 6 is as follows:

- X56 + X65 <= 1

Since the decision variables are binary, only X56 or X65 can be chosen or neither of them can be chosen when this constraint is imposed.

(e) The next constraint that needs to be formulated is the maximum area capability constraint. This is a factor of the aircrafts on-station time and how large of an area the aircraft can search in one hour. This model assumes that the aircraft has an on-station time of 8 hours with a loiter speed of 230 kts. With a detection range of 24 miles a maximum search area of 44160 was yielded. This is calculated by taking 230*24*8.

(f) Lastly the non-negativity, and binary constraints are added to the formulation for all of the decision variables:

- Xij >= 0 (non-negativity)
- Xij = Binary (1 or 0)

c. Objective Functions.

(1) Maximum Area Problem. The objective function for the maximum area problem is the sum of all of the areas that are being searched. This is inserted in excel as a sumproduct equation. Since the decision variables are binary, if the area is not chosen, the multiplier of the area will be zero and nothing will be added to the sum. If the area is chosen, a 1 is assigned and the correlating area will be added to the total areas being searched.

(2) Detection Rate Problem. The objective function for determining the maximum DR is the productsum of the DRs for each area that is being searched times a binary value. Again if 0 is assigned the DR will not be added to the sum and if a 1 is assigned the DR will be included in the summation of the DRs.

3. Results

When all formulated equations were entered into excel, the maximum area problem yielded an area of 39,213 sq mi with a DR value of 49. The maximum DR problem yielded an

area on 37,818 sq mi with a DR value of 49. Both routes are shown in Figures F.2 and F.3

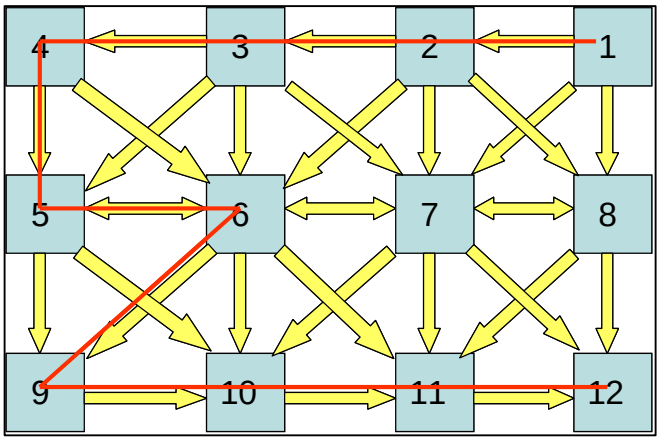

Figure F.2 Maximum Area Path Results

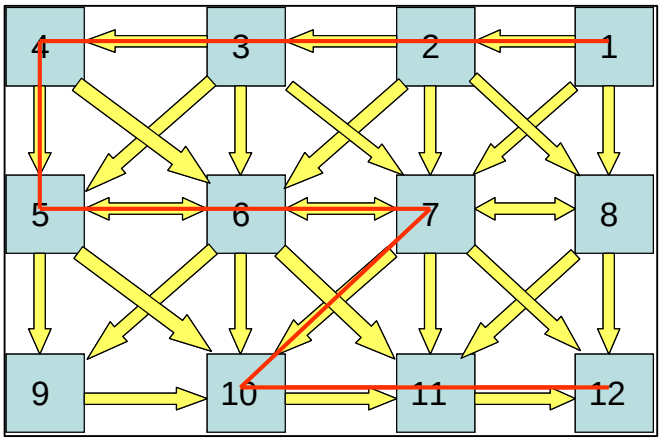

Figure F.3 Maximum Detection Rate Path

Table F.1 shows the excel spreadsheet of the results for the Maximum Area problem:

	Selected	Square Area	Detection Rating
X12	1	3922	5
X17	0	3922	5
X18	0	3922	5
X23	1	3871	6
X26	0	3871	6
X27	0	3871	6
X28	0	3871	6
X34	1	4254	9
X35	0	4254	9
X36	0	4254	9
X37	0	4254	9
X45	1	4546	8
X46	0	4546	8
X56	1	3888	3
X510	0	3888	3
X59	0	3888	3
X65	0	5271	5
X610	0	5271	5
X67	0	5271	5
X69	1	5271	5
X611	0	5271	5
X76	0	3286	4
X710	0	3286	4
X711	0	3286	4
X712	0	3286	4
X78	0	3286	4
X87	0	4751	2
X811	0	4751	2
X812	0	4751	2
X910	1	4681	1
X1011	1	4936	7
X1112	1	3844	2

Table F.1 Excel Results for Maximum Area Problem

4. Conclusions

This problem yielded the same DR for each path, but the maximum area path yielded a search area 1395 sq mi larger in size. A decision based on these results would lean towards patrolling the Maximum Area Path because the DR value is equivalent to that of the Maximum DR path. In other scenarios this may not be the case although the maximum area path will not change because the AOR area assigned will be the same, the DR values assigned to each Sector can change, and should change, based on the current intelligence and events.

5. Summary

The content of this example may not be relevant to the current situation in OIF or OEF, however, the technique used in the network flow model is applicable to many situations in the present conflicts. This model can be easily manipulated to meet the needs of a current problem.

ANNEX G: CRITICAL PATH METHOD

1. Purpose

a. General. This annex uses a Non-Combatant Evacuation Operation (NEO) scenario to show the functionality of the Critical Path Method (CPM) in determining the required time until execution of the NEO mission.

b. Background. As a member of the 29th Marine Expeditionary Unit (MEU) staff aboard the USS Hornet (LHD-9) Amphibious Ready Group (ARG), your unit is currently conducting port call in Greece after two months of operations in the Mediterranean Sea. You just received a warning order from CinCCent to recall all personnel from liberty in order to get under way en route to the country of Cantwait in the Persian Gulf region. There the MEU may need to conduct a Non-Combatant Evacuation Operation (NEO) in support of the American Embassy. The Central Intelligence Agency has uncovered a credible plot to overthrow the government of Cantwait and the State Department has requested that the MEU evacuate American citizens in anticipation of a possible coup d'etat or a civil war. This NEO will be a planning intensive, high-profile mission. CinCCent needs to know the soonest that the ARG can get the MEU to the area.

2. Critical Path Model

a. Problem. The MEU Commander has requested your skills to determine an estimated time until the NEO can be executed.

b. Definition of Model. The Critical Path Method (CPM) is a mathematically based algorithm for scheduling a set of project activities. It is commonly used with all forms of projects, including construction, software development, research projects, product development, and military applications. Any mission with interdependent activities can

apply this method of scheduling. If some of the activities require other activities to finish before they can start, then the project becomes a complex web of activities. An activity is a specific task. The essential technique for using CPM is to construct a model of the project that includes the following:

(1) A list of all activities (tasks) required to complete the mission.

(2) The time (duration) that each activity will take to completion.

(3) The dependencies between the activities.

(4) Cost to complete activity (optional)

(5) Shorter time to complete activity on a crash basis (optional)

(6) Higher cost of completing activity on a crash basis (optional)

Using these values, CPM calculates the starting and ending times for each activity, determines which activities are critical to the completion of a mission, critical path, and reveals those activities with "float time" (less critical). A critical path is the sequence of the mission network activities with the longest overall duration, determining the shortest time possible to complete the mission. CPM can also include resources related to the activities. This capability allows for the exploration of a related concept called the critical chain, which determines the mission duration from both time and resource dependencies. Items 4-6 above show the resource dependencies based upon "crashing" certain tasks that would require additional manpower or money. The book "Spreadsheet Modeling and Decision Analysis" has a detailed chapter (Chapter 14) on developing the spreadsheet model to execute the Critical Path Method (CPM).

c. NEO Activities. Based upon the example scenario, planners and analysts developed the network of activities. This network included the duration of each task and the dependencies on other tasks. The following table shows the tasks required to conduct the NEO mission:

Task #	Node Label	Task Description	ti (hrs)	ti-Ci (hrs)	Dependencies
1	A	Report to CinCCent	1	0	
2	B	Recall Liberty Personnel	12	8	A
3	C	Finish refueling / resupplying	12	10	A
4	D	Repair AN/SPY-9 Radar	12	10	B
5	E	Repair engines on 2 CH-53Es	20	18	C
6	F	Transit to Suez Canal	15	12	B, C
7	G	Bring together ARG	20	16	B, C
8	H	Passage thru Suez Canal	21	13	D, E, F, G
9	I	MEU NEO rehearsals	72	48	H
10	J	Break out, issue Ammo	24	24	H
11	K	Transit to Lesbos from Suez	60	48	H
12	L	Conduct NEO	Exec		I, J, K

Table G.1 Tasks Required to Conduct NEO

The column "ti" represents the time required to conduct the task under normal conditions. "ti-Ci" represents the time required to conduct the task under "crashing" conditions by adding additional manpower to the task or spending more

money to accomplish the task. The following network diagram depicts the dependencies of the task:

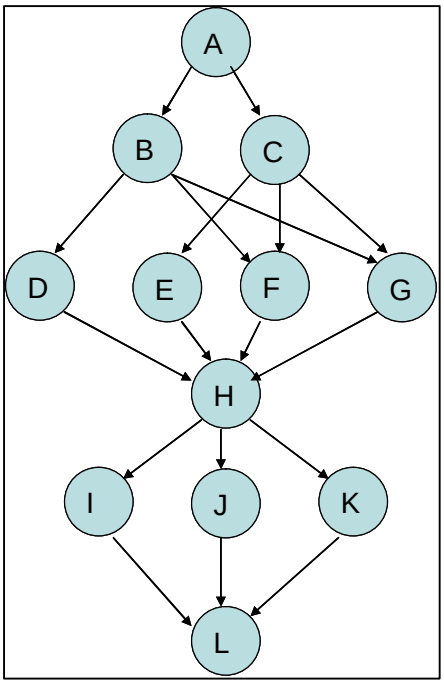

Figure G.1 Task Network

Figure G.1 shows the network of tasks from Node A (Report to CinCCent) to Node L (Conduct NEO). There are 18 arcs within the network. Now that the network of tasks is developed, Microsoft Excel can be used to calculate the different times it would take until execution of the NEO mission. The book "Spreadsheet Modeling and Decision Analysis" has a detailed chapter (Chapter 14) on developing the spreadsheet model to execute the Critical Path Method (CPM).

d. Analysis and Results. The data is now entered into Excel and formulas are developed to determine the critical

path of tasks. This critical path provides the estimated time necessary to NEO execution. Table G.2 shows the results of the Critical Path Model for time until NEO execution without consideration of the "crashing" factors (no crash):

Node	Ti	Ci	ti	Ci	Cost/Hour
Ta	0	0	1	0	$0.00
Tb	1	0	12	4	$1,250.00
Tc	1	0	12	2	$10,000.00
Td	13	0	12	2	$1,500.00
Te	13	0	20	2	$2,500.00
Tf	13	0	15	3	$1,000.00
Tg	13	0	20	4	$1,500.00
Th	33	0	21	8	$2,500.00
Ti	54	0	72	24	$0.00
Tj	54	0	24	0	$0.00
Tk	54	0	60	12	$2,667.00
Tl	126	0	0	0	$0.00
Minimum	126 hours until NEO Execution				
Total Crash Cost	$0.00				

Table G.2 Results of CPM (No Crash)

Table G.3 provides the results of CPM when "crash" factors are incorporated in the analysis and formulas:

Node	Ti	Ci	ti	Ci	Cost/Hour
Ta	0	0	1	0	$0.00
Tb	1	4	12	4	$1,250.00
Tc	1	2	12	2	$10,000.00
Td	9	2	12	2	$1,500.00
Te	9	2	20	2	$2,500.00
Tf	11	3	15	3	$1,000.00
Tg	11	4	20	4	$1,500.00
Th	27	8	21	8	$2,500.00
Ti	40	24	72	24	$0.00
Tj	40	0	24	0	$0.00
Tk	40	12	60	12	$2,667.00
Tl	88	0	0	0	$0.00

Minimum **88 hours until NEO Execution**

Total Crash Cost **$94,000.04**

Cost Constraint: **Unlimited**

Table G.3 Results of CPM (Maximum Crash)

If you crash all factors to the maximum extent, the time until execution would be 88 hours, but the cost to the government would be over $94,000. You can optimize the crash factors is a specified time between 88 and 126 hours is given or if you are given a constraint on the amount of money less than $94,000 to spend.

3. Summary

This problem shows the application of the Critical Path Model to a military scenario. Although one could determine the critical path from visually looking at the network of tasks, using Excel allows the analyst to quickly change parameters such as "crashing" factors. Furthermore, other network models may contain many more nodes, arcs, and constraints that would make visual analysis very difficult.

ANNEX H: Insignia for U.S. Military Services

1. Insignia of Grade Comparison for U.S. Military Services

a. Commissioned Officer.

	Army/Air Force/Marines	Navy/ Coast Guard
O-1		
	Second Lieutenant (Army - 2LT) (Air Force - 2d Lt) (USMC - 2dLt)	Ensign (ENS)
O-2		
	First Lieutenant (Army - 1LT) (Air Force - 1st Lt) (USMC - 1Lt)	Lieutenant Junior Grade (LTJG)
O-3		
	Captain (Army - CPT) (Air Force - Capt) (USMC - Capt)	Lieutenant (LT)
O-4		
	Major (Army - MAJ) (Air Force - Maj) (USMC - Maj)	Lieutenant Commander (LCDR)
O-5		
	Lieutenant Colonel (Army - LTC) (Air Force - Lt Col) (USMJ - LtCol)	Commander (CDR)
O-6		
	Colonel (Army - COL) (Air Force - Col) (USMC - Col)	Captain (CAPT)
O-7		
	Brigadier General	Rear Admiral (lower half)

	(Army - BG) (Air Force - Brig Ben) (USMC - BGen)	(RDML)
O-8		
	Major General (Army - MG) (Air Force Maj Gen) (USMC - MGen)	Rear Admiral (upper half) (RADM)
O-9		
	Lieutenant General (Army LTG) (Air Force - Lt Gen) (USMC - LtGen)	Vice Admiral (VADM)
O-10		
	General (Army - GEN) (Air Force - Gen) (USMC - Gen)	Admiral (ADM)
Note: The Navy also uses Air Force/Army/Marine style rank on the collar.		

b. Warrant Officer.

	Army	Navy/Coast Guard	Marines
W-1			
	Warrant Officer One (WO1)	Warrant Officer (WO1)	Warrant Officer (WO-1)
W-2			
	Chief Warrant Officer Two (CW2)	Chief Warrant Officer Two (CW02)	Chief Warrant Officer 2 (CW-2)
W-3			
	Chief Warrant Officer Three (CW3)	Chief Warrant Officer Three (CW03)	Chief Warrant Officer 3 (CWO-3)

W-4			
	Chief Warrant Officer Four (CW4)	Chief Warrant Officer Four (CW04) Note: According to NAVADM Message 337-02, Nov 2002, the Secretary of the Navy has authorized implementation of W-5 for the U.S. Navy Beginning in Fiscal Year 2004).	Chief Warrant Officer 4 (CWO-4)
W-5			
	Master Chief Warrant Officer (CW5)		Chief Warrant Officer 5 (CWO-5)
Note: The Air Force does not have Warrant Officers.			

c. <u>Enlisted.</u>

	Army	Navy/Coast Guard	Air Force	Marine Corps
E-1	No insignia		No insignia	No insignia
	Private (PV1)	Seaman Recruit (SR)	Airman Basic (AB)	Private (PVT)
E-2				
	Private (PV2)	Seaman Apprentice (SA)	Airman (Amn)	Private First Class (PFC)
E-3				
	Private First Class (PFC)	Seaman (SN)	Airman First Class (A1C)	Lance Corporal (LCpl)
E-4				
	Corporal (CPL)l	Petty Officer Third Class (PO3)	Senior Airman (SrA)	Corporal (Cpl)
				
	Specialist (SPC)			
E-5				

	Sergeant (SGT)	Petty Officer Second Class (PO2)	Staff Sergeant (SSgt)	Sergeant (Sgt)
E-6				
	Staff Sergeant (SSG)	Petty Officer First Class (PO1)	Technical Sergeant (TSgt)	Staff Sergeant (SSgt)
E-7				
	Sergeant First Class (SFC)	Chief Petty Officer (CPO)	Master Sergeant	Gunnery Sergeant (GySgt)
				
		(Collar & Cap)	First Sergeant (Master Sergeant)	
E-8				
	Master Sergeant (MSG)	Senior Chief Petty Officer (SCPO)	Senior Master Sergeant (SMSgt)	Master Sergeant (MSgt)
				
	First Sergeant (1SG)	(Collar & Cap)	First Sergeant (Senior Master Sergeant)	First Sergeant (1stSgt)
E-9				
	Sergeant Major (SGM)	Master Chief Petty Officer (MCPO)	Chief Master Sergeant (CMSgt)	Master Gunnery Sergeant (MGySgt)
				
	Command Sergeant Major (CSM)	(Collar & Cap)	First Sergeant (Chief Master Sergeant)	Sergeant Major (SgtMaj)
				
			Command Chief Master Sergeant	

Sp Pay Gd				
	Sgt. Major of the Army (SMA)	Master Chief Petty Officer of the Navy (MCPON)  (Collar & Cap)	Chief Master Sergeant of the Air Force (CMAF)	Sgt. Major of the Marine Corps (SgtMajMC)

Note: In the Army, there are two types of E-4s: corporals and specialists. While both receive the same pay, a corporal is a noncommissioned officer and a specialist is not. An E-4 is normally designated an NCO (corporal) if they are a team or section leader. Corporals are more common amongst the Combat Arms, but many Combat Support MOS's (jobs) may have them. In the Army and Marine Corps, First Sergeant is a rank (E-8), and special duty position held by the top E-8 enlisted person in the unit. In the Air Force, first sergeant is a special duty position which can be held by those in the rank of E-7, E-8, or E-9 (The authorized rank of an Air Force First Sergeant is dependent upon the size of the unit. The more enlisted personnel assigned, the higher the rank of a first sergeant that unit is authorized).

ANNEX I: GLOSSARY